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Glaciological Investigations According to the IGY Program on Franz Josef Land

by M. G. Grosval'd and V. L. Sukhodrovskiy

On the major glacial areas of the Soviet Arctic, Franz Josef Land, is an island group situated on the northern edge of the Eurasian continental shelf between 79°45' and 81°51' lat. N and 44°45' and 65°25' long. E. It numbers over 150 islands, whose total area equals 16,495 sq. kms.

Franz Josef land is formed by Triassic and Jurassic platform deposits, which have been covered over and incised by basalts of Cretaceous age. In the Cenozoic, this mass was broken up into a series of blocks and uplifted to an average of 150-200 m above sea level. Its tabular structure determined the plateau-like relief of the islands which, in turn, in many ways affected the shape and extent of glaciation and favored the growth of extensive ice covers.

The other, basic, condition governing glaciation has to do with the low position of the climatic snow line in the island group area, due to its position in high latitudes, the cooling effect of ice-containing waters surrounding the islands, and cyclonic activity, favoring the arrival from the west of air masses high in moisture content. It is precisely for these reasons that Franz Josef

Land, which, in total glaciated area, ranks only third in the Soviet Union, following Novaya Zemlya and Severnaya Zemlya, is far ahead of both these regions in the intensity of its glaciation. According to data obtained by aerial survey, 86.9 percent of the area of the island group, or 14,330 sq kms, is under ice. Such an extent of coverage of land by ice makes the latter the major feature of the landscape on these islands, and makes for analogy between Franz Josef Land and Antarctica and Greenland.

Glaciation in the island group is of the sheet type. Its morphology, as a whole, is that characteristic of ice-covered areas in polar regions. The basic features of the ice cover are the flattened ice domes of the plateau-like divides, in which ice thickness at times exceeds 300 m, and the various "drainage" glaciers fed by the domes and which vary from short and broad tracks to complex valley and piedmont glaciers. The termini of these glaciers nearly always reach the sea and frequently form floating lobes or small ice shelves.

The features noted in the glaciation of Frans Josef Land make the latter an interesting and important subject for glaciological and glacio-climatological investigations. At the same time, it has obviously been studied insufficiently until now. Arctic expeditions which have studied the island group or have used it as a base for reaching the North Pole were hardly interested in glaciation. Only a few investigators have made isolated glaciological observations while engaging in other studies.

A beginning in specialized studies of glaciation in Franz Josef Land was made by an expedition of the Arctic Institute (1947-1952), based in Tikhaya Bay on Hooker I. Most of the work of the expedition took place on the Churlyanis dome and on the Sedov and Yuriy glaciers in the northern part of the island. These researches led to the gathering of most valuable materials pertaining to the morphology, equilibrium, thermal regimen and history of glaciation, and the motion and structure of the ice. The infiltration process of ice-formation was identified for the first time in the Soviet Arctic on the domes of this island group.

The glaciological expedition to Franz Josef Land during the IGY was organized by the Institute of Geography of the Academy of Sciences USSR. The work of the expedition is slated to extend over a period of two years, from summer 1957 to summer 1959. As in 1947-1952, the subject chosen for study is again the Churlyanis dome and the Sedov and Yuriy glaciers on Hooker Island, so as to ensure continuity

in the studies and to obtain comparative materials in all major types of observations.

The expedition left Arkhangel'sk on 21 June 1957 on the diesel ship "Nemirovich-Danchenko", and arrived in Franz Josef Land on 26 July. Its arrival to its destination in Tikhaya Bay was preceded by a 20-day stopover on Heiss Island. This time was used in routine studies of the ice dome on that island. For the first time, description and mapping was possible of the system of marginal channels testifying to the rapid retreat of the edges of the dome, and allowing an estimate of this retreat as equalling 130-150 m over the past 30 years. Data were also gathered on the discharges of streams carrying glacial melt water.

On 16 August, the expedition landed on Hooker Island. The main scientific base of the expedition was set up on the summit of the Churlyanis dome, in the zone of snow accumulation and transformation. A secondary base was set up in the ablation zone, on a lateral moraine of the southern margin of the Sedov glacier.

Installations on the Churlyanis dome included a weather station, a snow platform, equipment for actinometric observations and for the stationary study of the temperature regimen of the glacier, and a "cold" and a "warm" laboratory. A power station and two dwellings have been built. In addition, it was possible to free of ice and rebuild the structure left by the expedition of the Arctic Institute.

A weather station and a snow platform were also set up at the "Sedov Glacier" station, and a dwelling has been built for the observers.

As construction proceeded, work was also initiated to set up markers for studying the motion and the equilibrium of matter on the surface of the glacier. In August-September 1957, markers had been set up along a transverse line across the Sedov glacier, in a broad band along its longitudinal axis, and along two lines intersecting at the apex of the dome, 96 markers in all. Prior to the fall of the polar night, a triangulation was completed, which joined the glaciological markers and the bench marks set up on the nunataks into a single net. In addition to the newly installed markers, the net also included markers "inherited" from the expedition of the Arctic Institute. This makes possible a comparison of the data of that expedition on rates of motion and the accretion-attrition equilibrium in various parts of the surface of the glaciers with the results of our measurements.

During the daylight period of 1958, i. e., in the interval from April to September, two series of repeated

triangulation operations were performed, one in spring, the other in autumn. The first covered the Sedov glacier, while the second covered both it and the Churlyanis dome. At the same time, a survey was performed of the seaward edge of the glacier, and markers were set along additional lines: along a transverse cross section of the Yuriy glacier, on the Medvezhiy residual glacier, along the Avsyuk valley glacier, and along the perimeter of the foot of the dome, 86 markers in all. A series of operations necessary to define their positions was also completed.

The markers are used for systematic observations of changes in the levels of ice and snow. The initial readings of these levels for all markers were taken upon their installation, at a time which coincided with the beginning of accumulation (September 1958). Subsequently, readings were taken every month on 40 markers. In the ablation period, in July 1958, readings were taken every 10 days. Observations on all markers were performed again at the end of the accumulation period, in June, as well as the time of maximum ablation, in the end of July. The June observations were complemented, in addition, by a snow area survey, using the trenching method, in the course of which cross sections were described and snow compactness was determined at 125 points.

Observations of the snow cover follow a broader program on the Churlyanis dome. Here, a survey of snow compactness, observations of the snow level by means of control rods and measurements of the hardness of the snow surface by means of a conic hardness gage are performed every 10 days on a snow platform measuring 100 x 20 m. The survey included determinations of compactness at 20 points and the description of the snow profile. A description of the profile every 10 days and the determination of the compactness of the snow are also performed at the "Sedov Glacier" station.

In addtion, on the dome, measurements were made of the drifting of snow, by means of BO-2 drift gages, which were installed for this purpose simultaneously at three levels (snow surface, 20, and 200 cm above it), several measurements of evaporation were performed with weighing snow evaporators, and determinations were made of the amount of hoarfrost formed by collecting it from an area of one sq. m. and weighing it. The characterization of the snow cover is complemented by descriptions of the micro-relief of the snow which are systematic on the snow platform, and episodic and routine outside its limits.

A second source of data for estimating the equilibrium

of matter (as well as thermal balance) in the glaciers are weather observations. These are made at the weather station of the Churlyanis dome (altitude: 351 m) and that of the Sedov glacier (altitude: 64 m).

As early as the end of August 1957, temperature, humidity and pressure recorders had been installed on the dome, while beginning 1 October, climatological intervals (1, 7, 13, and 19 hours, mean solar time) have been used to schedulc regular observations of the temperature and humidity of the air, of the temperature at the surface of the snow (ice), of wind, using a weather vane set on a nine-meter mast, of atmospheric pressure, using a mercury barometer, of precipitation, using a Tretyakov precipitation gage (the containers are changed every 4 intervals), of snow level, and of atmospheric frost using a frost scope. The duration of solar radiation is recorded by a heliograph. Cloud cover, atmospheric phenomena and polar auroras are under continuous observation.

The weather station "Sedov Glacier" went into operation on 1 December 1957, following a somewhat more restricted program. The same 4 intervals are used for observations of the temperature and humidity of the air, the temperature on the surface of the snow, atmospheric pressure, using an aneroid barometer, precipitation, wind, using an ARME directional wind gage, set on the eight-meter mast, and snow level. The station is equipped with weekly recorders of temperature, pressure and humidity.

The majortypes of actinometric observations are performed at the "Churlyanis dome" station. Along with a weather platform, it includes a shed, housing galvanometers. The roof bears a heliograph, an actinometer, a pyranometer and an actinometric column with a balance gage and an albedometer. Observations were initiated in October 1957. During the polar night, observations were made only with the balance gage at each of the four climatological intervals. After sunrise, these were increased to a frequency of eight times in 24 hours, and were made at 0, 3, 6, 9, 12, 15, 18 and 21 hours true solar time. They included direct, scattered and total radiation, radiation balance, and surface albedo. In addition, 4 twenty-four series of measurements were made of radiation balance, of the temperature of the air, and of the temperature of the underlying surface, 2 each during polar day and night. In May a series of observations of this type encompassed all forms of radiation.

During daytime, observations are made in the field of radiation balance and albedo on the slopes of the dome, on the surfaces of the Sedov glacier, on nunataks, on the

shoreline terraces and on the sea ice of the bay, as well as periodic measurements of the total radiation that penetrates into the snow layer, using a sub-surface pyranometer, set at depths of 5, 10 and 20 cm. Finally simultaneous observations with the balance gage are performed daily once in twenty-four hours at 01 hours at stations "Sedov Glacier" and "Churlyanis dome".

Lapse rate observations on the dome are performed eight times in twenty-four hours at the same intervals as the actinometric observations. They were initiated in February 1958. Until the middle of May, their program included measurements of the temperature of the air and wind velocity at the 0.5 and 2 m levels, and of the temperature of the snow at depths of 10 and 30 cm. After the temperature had risen, in the middle of May, measurements of wind velocity, and temperature and humidity of the air were initiated at four levels: 0.25, 0.50, 1 and 2 m, using cup anemometers and Assman psychrometers, while temperatures of the snow cover were taken at depths of 5, 10, 15 and 20 cm with Savinov soil thermometers.

Apart from daily lapse rate observations on the dome, series of determinations of wind velocity, air temperature and humidity at the 0.5 and 2 m levels with simultaneous measurements of radiation balance were conducted from June to September 1958 at the "Sedov Glacier" station.

In February 1958, regular studies were begun of the temperature regimen of the glaciers. On the dome, these involve a 15-m drill hole, into which are lowered semiconductor resistance thermistors to depths of 10, 20, 30, 50, 75 cm; 1, 1.5, 2, 2.5, 3, 4, 6, 8, 10, 15 m. Simultaneously, temperature readings are taken with semi-conductor resistance thermometers set at the point of contact between the ice and the snow*, at intervals of 10 cm within the snow layer, and on a mast at elevations of 2, 4, and 6 m above the surface of the ice. Readings are taken telemetrically from these thermometers in the structure containing a direct current bridge and a mirror galvanometer. Readings of the temperature of the air, and of the snow and ice to a depth of 3 m are taken 4 times in 24 hours at climatological intervals, and once in twenty-four hours, at 13 hours, for depths below 3m.

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*Firn is practically absent on the Churlyanis dome, in the feeding area of which ice-formation takes place by the infiltration process.

Since the completion of the drilling of a 70-meter drill hole on the dome (June 1958), ice temperature is being measured in addition at depths of 20, 30, 40 and 50 m, likewise by means of semi-conductor resistance thermometers, which are read once every five days. A second deep drill hole (45 m), on the northwestern edge of the dome near the level of the snow line, is used for semi-stationary observations. In it, the temperature of the ice and of the upper 2.5 meters of the underlying deposits is measured once every 10 days with a sliding thermal probe.

Studies of the temperature of the ice were begun in September 1958 at the "Sedov Glacier" station. Readings are scheduled at the same intervals as on the dome, and are taken from a 15-m drill hole, drilled by means of a hand auger.

In addition to the stationary temperature measurements, a "temperature survey" was performed in May-June to include 10 points on the Churlyanis dome. It was carried over on to the Sedov glacier in September. In this survey, temperatures are measured by means of thermal probe driven into 12 levels in hand-drilled 5-meter drill holes. To obtain data on the heat content of the layer, field determinations are made of the compactness and porosity of the ice removed from the drill holes. Several of the drill holes are equipped with semi-conductor resistance thermometers; in them, observations of ice temperature are semi-stationary, and take place once every 10 days.

Among other work involving the field study of the thermal properties of ice, we may mention measurements of heat flow at various levels within snow, ice and frozen ground by means of A. Z. Dmitriev thermotransitometer sets, which are conducted episodically in the form of twenty-four series of hourly observations.

For ice drilling, the expedition uses an SBU-150-ZIV rig, mounted on three-axle truck. The 70 and 45-m drill holes mentioned earlier were drilled by the core procedure*. The drilling is by means of a core rig 116 and 100 mm in diameter. To remove ice dust from the hole, we use a compressor, which replaces the mud pump, a slime pipe being incorporated into the equipment for collecting the dust. The bit is prepared from the end of a core pipe in the form of a crown drill bit, the usual bit having been found

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*To the authors' knowledge, core drilling has not been used heretofore in solid ice.

unsuitable for drilling in ice because of the insufficient projection of the cutters.

Ice core samples, samples collected at ice cliffs, crevasses and special excavations, as well as blocks removed at ten-day intervals from trenches in the snow platforms are forwarded to the "cold" laboratory for the study of the physical and mechanical properties of the ice and snow. The laboratory is hacked out of the ice to a depth of 10-meters in the glacier. It has an area of 20 sq. m. and consists of three rooms: a core sample storage room, a room for the preparation of sections, and the laboratory proper, in which the temperature remains $-9.8^{0} \pm 0.2^{0}$ the year around. In the laboratory, ice tables and niches are used as emplacements for polarizing and binocular microscopes, a photopolarizing apparatus, Tsytovich and Malmgren apparatus, an ultrathermostat, scales of hydrostatic weighing, and other equipment designed for the study of the structure, compactness and porosity of ice and snow, of their thermal and mechanical properties (heat conductivity, temperature conductivity, elasticity, cohesion, etc.). In the "warm" laboratory, pressure is measured in air bubbles, analyses are made of moraine deposits, samples of melt water, etc.

Contemporary glaciomorphological processes and glacial deposition are investigated mainly by means of field sorties which covered, during the first year of work, the Sedov, Yuriy, Avsyuk, Shumskiy, Medvezhiy and Malaniy glaciers, as well as adjacent land areas devoid of ice. In the course of these trips, materials have been gathered concerning the composition, structure, and mode of formation of present-day moraines, as they relate to tectonic formations and the motion of the glaciers. A number of observations have born on relief forms on glacier margins, in particular marginal channels, marine terraces and littoral embankments.

Field investigations are being brought to bear on frozen deposits and relief forms associated with contemporary geocryological processes and, specifically, the supply pattern of depositional materials for contemporary moraines. To obtain some quantitative measure of the intensity of these processes, installations have been set up on the slope of the northern edge of the Sedov glacier consisting of barriers which catch falling erosional material, and in portions of the slope, of rods buried to varying depths in the "active" layer, subject to solifluxional flow. The displacement of these rods provides an idea of the magnitude of solifluxional "drainage" of friable deposits from the slope

to the margin of the glacier.

* * *

The work of the expedition is, as yet, far from completed, and the results of the observations have been hardly processed at all. Nevertheless, it is already possible to present a few conclusions, of course, highly preliminary in nature, concerning the regimen, past history and climatic conditions attending glaciation.

First of all, it should be stated that the totality of the facts gathered indicates the recession of glaciation in the island group. This is evident from: the rapid recession of the margins of all the domes studied, as "marked" by the marginal channels, from the accretion-attrition balance of the upper surfaces of the domes, which is close to zero or even negative and the gradual reduction of their height*, the wide distribution of residual glaciers in the island group** which are losing or have lost their connection with domes, the reduction of the size of glacier lobes and the formation of inert ice in their peripheral portions, and the noticeable reduction in recent years of the rate of motion of valley glaciers***.

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*A new leveling in autumn of 1958 showed that a bench mark set on the apex of the Churlyanis dome in 1950 had been lowered 2.5 m in relation to the surface of the basalt plateau over an interval of eight years. Inasmuch as only one third of amount was found to be compensated by the accretion of ice, the "net", i. e. non-compensated lowering of the dome in that interval amounted to 1.6-1.7 m, yielding a rate of lowering of the order of 20 cm a year. Apparently, smaller domes are receding even more (the Sedov dome, for example), and practically lack feed zones.

**Until recently, most of the residual glaciers were considered as belonging to the "drift" type. In the light of our observational data, this is erroneous.

***The Sedov glacier, for example, has reduced its maximum rate of flow from 70 to 53-55 meters anually over the last 10 years.

For the first time, proof has been obtained of the fact that the recession of glaciation observed at the present time began, as shown by data from over a period of many years, with "continentality". This is apparently not an accident, but stands in relation to the increasing coldness of Arctic climate noted in recent times. According to the data of the weather station of Tikhaya Bay; the mean temperatures of all winter months, except January; were 3-6° below the averages for a period of several years, the autumn and spring were also somewhat colder than "normal", and the summer was shorter, though noticeably warmer. Precipitation was also reduced. The mean annual temperature at Tikhaya Bay (-12°2) was found to be 1.8° colder than the average over several years. On the dome, it was also about 2° below (-14.1) the temperature of the ice in deep drill holes, reflecting the mean temperature of the air over a period of many years. Apparently, the trend toward a colder climate or, more exactly, its change in the direction of more pronounced continentality, at least in its present stage, continues to favor the recession of glaciation which began under somewhat different climatic conditions.

The meteorological observations of the expedition in various glaciological zones, and the comparison of the data therefrom with the data from Tikhaya Bay reveals substantial differences in all climatic features. The importance of these differences is particularly great for the matter equilibrium of the glaciers during the ablation period (July-August). Mean temperatures for these two months amounted to +0.8° in Tikhaya Bay, to -0.3° at the "Sedov Glacier" station, and to -1.4° on the dome. On the dome, even July (which was abnormally warm that year) was characterized by a sub-zero mean temperature. The effect of low temperatures in reducing the intensity and duration of ablation in the feed zone of the glaciers is intensified by nearly constant radiation and adiabatic fogs. Thus, while the total duration of fog in July-August in Tikhaya Bay was 125 hours, this duration was 10 times as great on the dome, amounting to 1180 hours or 80 percent of the entire ablation period. At the same time, fogs act to reduce considerably (by 1.7 times, according to the data of the expedition) the amount of heat that is received by the snow through radiation.

Franz Josef Land
Hooker I.

IGY 1958

Fig. 4. General view of station "Sedov Glacier"

Description of the Points of Observation of the Novaya Zemlya Glaciological Expedition

The Novaya Zemlya Glaciological Expedition is conducting investigations of the ice shield on North Island of Novaya Zemlya in the area of Russian Harbor, under the program of scientific research by the Soviet Union during the IGY. These studies are a continuation of a study of the Shokal'skiy glacier and of its feed area initiated by the glaciological expedition of the 2nd International Polar Year of 1932-1933 under the leadership of M. M. Yermolayev.

Despite the high latitudes in which the Russian Harbor area is situated, the mean annual temperature of the air (-8°) is here considerably higher than further east at the same latitudes. This is due to a considerable flow of heat from the Barents Sea. Thus, for example, the mean January temperature over a period of years in Russian Harbor is -17°.4, but falls to -20°.4 over a distance of 70 kms in Blagopoluchiye Bay.

During the warm part of the year, the mean monthly temperature does not rise above +3°.9 (July), and may be above zero during four months. However, freezing spells are possible on any day, and thaws may likewise occur in winter.

Measured total precipitation is approximately 160 mm, but is doubtless reduced by drift of snow out of the precipitation gage as a result of the strong winds that usually accompany snow falls.

The proportion of hoarfrost in the supply of the glacier is considerable above the snow line. A stable continuous snow cover does not form at elevations below 300 m, as a result of very strong southerly winds, attaining 40 meters per second, which frequently carry the snow out to sea during the winter.

Ice also covers all of the dry land in the area of Russian Harbor. Only occasional high points on the periphery of the ice shield and the rocky littoral plain (strandfleet) are free of ice up to an elevation of 100 m. The latter supports a poor vegetation of Arctic desert type, which includes isolated specimens of a few phanerogamia: saxifrage, whitlow grass, polar poppy, dryads, trailing willow, which grow in sheltered depressions near fissures and under the protection of large slabs of fallen rock. Also found are occasional bands and patches of mosses and lichens. Scaly lichens are the only plant cover of the gravel deposits of nunataks.

The Shokal'skiy glacier is one of the many outlet lobes of the glacial shield of Novaya Zemlya. It measures about 5 km in length and 3.5 km in width. The coordinates

of its frontal termini are 76°09.5 – 62°28' E and 76°11'.5 – 62°34' E. The body of the glacier is curved toward the northwest, and is very minutely fragmented by large crevasses. The glacier originates from the ice of a large field, situated below of the ice fall "The Barrier of Doubts", and fed in turn by the ice of the central portion of the shield.

The surface of the Shokal'skiy glacier rises on an incline from 12-20 m in its frontal area to 150-170 m at its origin. The angles of slope of the surface of the field which feeds the glacier are approximately the same, but decrease at the foot of the "Barrier of Doubts"; where the elevation of the surface attains 300-320 meters. The grandiose cliff of the ice fall raises the surface of the glacier to 400-430 m. K. Vel'ken, a member of the expedition of the 2nd International Polar Year discovered here by seismic sounding a sub-glacial terrace about 350 m in height, the foot of which sinks below sea level. Above the "Barrier of Doubts", the surface of the shield rises on an incline toward the water divide, being subject to a new abrupt increase in elevation only at the "Yablonskiy Barrier", a steep cliff whose relative elevation is about 50-70 m, and which is situated 20 kms on a straight line south of the front of the glacier. It is on its rim that the snow line of the ice shield passes at an altitude of 570 m. On the meridian of Russian Harbor, the ice divide of the shield is at an altitude of 776 m, 35 kms to the south of the front of the Shokal'skiy glacier.

The Novaya Zemlya glaciological expedition is to conduct observations in order to determine:

1 – the morphology and dimensions in depth of the glacier and present trends in their variation;

2 – conditions of the supply and ablation of the glacier and a quantitative measure of its equilibrium of matter;

3 – the structure and composition of the glacier, as well as the physical and mechanical properties of the ice and firn forming it;

4 – the thermal regimen of ice layers and of the upper layers of the lithosphere, and their thermal equilibrium;

5 – ice motion in the glacier;

6 – the regimen, morphology, structure and properties of the snow cover of the glacier and surrounding areas;

7 – features of drainage of the melt water of the glacier;

8 – the geological and geomorphological activity of the glacier, the features of contemporary geocryological and other exogenous relief-forming processes, of underground ice and friable deposits.

The necessary data are obtained from systematic stationary observations and single or episodic observations and surveys by field parties. For these purposes, the expedition has set up several permanent and episodic observation points, and has laid out a number of lines and base lines (Table 1 and Fig. 1).

Table 1

Observation points of Novaya Zemlya Glaciological Expedition

Name of point	Type of observations	Date of establishment	Coordinates lat.	Long. E	Absolute elevation of platform in meters
Ice divide Sta.	Permanent	15.X1.57	75°52'	62°44'	776
Barrier of Doubts Sta.	Permanent	18.X.57	76°07'	62°39'	234
Volod'kin Bay Sta.	Permanent	1.X1.57	76°13'	62°42'	11
Usachev Lake Post	Episodic	21.V.58	76°09.5	62°44'	150

Apart from its own observations, the expedition makes use of the results of weather observations at the Polar Station of the Main Authority of the Northern Maritime Passage at Russian Bay. This station is situated 600 m north of the northeastern terminus of the front of the Shokal'skiy glacier, and has been conducting continuous weather observations since September 15 1932.

Between the Bastiony Mountains and the ice shed bordering on the Chayev Glacier, north of the Barrier of Doubts, 11 markers have been installed at intervals of 1 kilometer, for the measurement of ice motion once every 3-5 months by geodetic methods. On Yermolayev Mountain and at an elevation of 198, base lines were laid out in May 1958 for the quarterly determination of the rate of motion of the ice and the mapping of the glacier by the

method of terrestrial stereophotogrammetric surveying. Similar base lines have been laid out on the Strel'cheni Peninsula and Shcheuretskiy Cape for mapping the glacier and photographing its front every half-year. A theodolite and a level for measuring the twenty-four hour rate of motion of the ice are being set up every month, from March 1958 onward, on the moraine at the northeastern terminus.

Special lines for observations of the snow cover have been laid out along the axis of the Shokal'skiy glacier and of the portion of the ice shield adjacent to it which feeds it, as well as along the western and eastern margins. Transverse lines have been laid out at the latitudes of Yermolayev Mountain, the Barrier of Doubts and Anchorite Oasis. Approximately half way between the Yablonskiy Barrier and the Ice Divide Station, a closed traverse has been laid out, consisting of ten snow-measuring markers, from which markers have been aligned toward the end-points of the western and eastern longitudinal profiles. The total length of the snow-measuring profiles is close to 120 kms. Readings on the markers are taken every 3-5 months.

Hydrological observations are being made at the mouths of streams in marginal valleys of the Shokal'skiy glacier.

At the glacier stations, meteorological actinometric, temperature and lapse rate observations are made according to the four-interval schedule. Periodic measurements are made of the thickness, compactness and hardness of snow cover, together with descriptions of its structure. Estimates are made of the direction and intensity of wind-caused snow drift. Measurements of the temperature within the ice layer began on January 19 1958 at the Ice Divide Station, and on 26 May 1958 at the Barrier of Doubts Station.

The Ice Divide Station is situated at 34-35 kms (in a straight line) south of the mid-point of the front of Shokal'skiy Glacier, on the even and flat surface of the ice shield near the ice divide. When visibility is total and the weather is clear, it is possible to note a slight grade in the surface of the shield to the south and north of the station. To the west and east, the surface of the shield rises slightly, forming the inclined slopes of the western and eastern glacial domes whose elevation readings are, respectively, 880 and 900 m.

In the area of the Ice Divide station, the glacial ice of the shield is capped by a 15-meter layer of shifting

layers of firn ice and firn, covered by fresh snow*. Already at a few hundred meters away from the station, crevasses occur in the firn, with widths up to 1 m. They are covered by one-and-a-half to two-meter caps of snow.

The Ice Divide Station consists of a weather platform, living quarters**, and a laboratory for the study of the structure and physico-mechanical properties of snow and ice (Fig. 2).

The weather platform is situated 50 meters to the west of the living quarters. On the platform are installed: three psychrometric housings for an August psychrometer and thermometers for extreme temperature readings, twenty-four hour and weekly thermographs and hygrographs; wild weather vanes with light-weight and heavy-weight plates, whose shafts on June 10 1958 were situated 450 cm above snow surface, a Tretyakov precipitation gage, a universal heliograph, an actinometric indicator with an actinometer, a pyranometer and a balance gage, and two two-meter portable masts for lapse rate observations by the Budyko method. Next to the weather platform there is a fifteen-meter drill hole containing platinum and semi-conductor electro-thermometers at depths of: 01, 0.2, 0.3, 0.5, 0.75, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 6.0, 8.0, 10.0 and 15.0 meters, and a plywood housing for reloading the self-recorders and measuring the resistance of the platinum electro-thermometers. Surface soil thermometers are installed on the surface of the snow a few meters from the psychrometric housing.

62 meters away from the shaft of the vane with the heavy plate, wooden snow-measuring markers are installed so as to form a square with sides measuring 46 meters. The corner markers are the points at which descriptions and measurements are made of the basic characteristics of the snow layer: thickness, structure, compactness by layers, and hardness.

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* 131 cm of snow (an average from readings at eight markers) fell during the interval from 5 September 1957 to June 10 1958.

** The structure is of insulated frame type (wood shavings, fiber packing). The inhabited portion, weather-proofed with felt and plywood, has a brick stove, an area of about 15 sq. m. and is separated from a 7 m square cubicle for the storage of coal, provisions and camping equipment.

At approximately 40 meters to the ESE of the dwelling at the station, a room has been excavated in the firn layer (measuring 2.5 x 4 meters) for use as a laboratory for the study of the structure and physical and mechanical properties of snow and ice. At the top, the room is covered by boards and buried under 1 meter of snow. The S-shaped entrance to the laboratory has 3 doors. Electric power is supplied to the laboratory from a 750 watt power unit, installed in a housing on a sled. The laboratory is equipped with industrial and analytical scales; polarizing microscopes with microphotographic attachments, a device for determining gas content and pressure in ice; a device for determining the permeability of snow to air, sovtoroye equipment, an ultrathermostat, and other apparatus.

80 meters to the northeast of the dwelling, a trench was excavated to a depth of 25.4 m in May 1958 for the study of the structure of the firn layer and of the upper levels of the glacier ice.

The Barrier of Doubts station (Fig. 3) is situated on blue glacier ice 2-2.5 kilometers to the north of the foot of the ice fall of the Barrier of Doubts. The weather platform and the dwelling unit of the station are situated on an even flat portion of the glacier, which has a hardly noticeable slope to the east and southeast. This is the direction of the drainage of melt water, which washes out shallow and narrow gulleys. The water flows into the glacier through the ice wells of the station.

As close as 30-40 meters to the north of the dwelling unit, the surface of the glacier acquires a clearly evident inclination toward the north, and the first crevasses makes their appearance and rapidly increase in size. To the west and east of the station stretch gently rolling portions of the glacier. At the latitude of the station on the western margin of the glacier, there extends a zone strongly dissected by crevasses. This zone abutts to the Bastiony mountain range (whose elevations are of the order of 600-650 meters). To the east of the station, a rolling and, in spots, as it were hilly portion of the glacier gradually rises, levels off imperceptibly at the latitude of the station, and acquires an inclination toward the adjacent Chayev glacier. There are no crevasses in that area. They arise somewhat further to the north, separating off a band of scarcely moving or immobile ice near the lateral moraines in the vicinity of Usachev Lake and further north at the foot of Yermolayev Mountain.

The dwelling unit of the station is similar in construction and plan to that of Ice Divide station, and is

located 50 meters to the north of the weather platform. The weather platform bears the same instruments as the Ice Divide station*. Their positions are shown in Fig. 4. The height of the vane with the light-weight plate is 540 cm, while the vane with the heavy-weight plate is 620 cm high**.

The "Volod'kin Bay" station is situated on an ancient shore line at the innermost point of Volod'kin Bay of Russian Harbor. A psychrometric housing for an August psychrometer and thermometers for extreme temperature readings and a Wild vane with a heavy plate (height of shaft 5.5 m) are set on the crest of the shore line. A Tretyakov precipitation gage is set 100 meters to the southwest of the psychrometric housing. Ground temperatures are measured by semiconductor electro-thermometers on slopes of western and southern exposures and on the water shed at elevations of, respectively, 23.07, 19.72 and 47.1 m. Savinov soil thermometers have been placed in trenches of western exposure and on the watershed. Above-ground thermometers have been installed two meters to the east of the psychrometric housing. After observations of soil temperatures had begun on the western exposure slope (at 265 meters to the east of the psychrometric housing), the above-ground thermometers were transferred to the opening of the trench containing semi-conductor thermometers.

The "Volodkin Bay" station has a remotely operated weather station. Its wind direction and velocity recorder is set on a four-meter high post over the ridge-pole of the living quarters at an elevation of 11.5 m above ground level. The temperature gage is set on a bracket on the same post at an elevation of 175 cm over the southern eave of the roof.

The living quarters are used for determinations of the specific gravity and moisture content of soils. During the winter, the testing of equipment and the first investigations of the structure and physical and mechanical proper-

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*The temperature-measurement drill hole has a depth of 30 meters. The temperature gages at depths over 15 m are installed at the 20, 25 and 30 meter levels.

**The station is situated in the ablation zone of the glacier. 200 cm of ice, not counting snow, melt here in the course of the summer. About 1 meter had melted by the end of July. The weather vane posts were not re-set.

ties of snow and ice were performed in a special wing added on the north side to the building containing the power unit.

The "Usachev Lake" post was set up for conducting hydrological observations at Usachev Lake and the stream which issues from it. The post is set up in movable heated building set up in skids, measuring about 6 sq. m. and having an iron stove. The building contains a table, a two-level bunk and a small cupboard.

The observations made by our expedition have confirmed the conclusions of glaciologists P. A. Shumskiy, G. A. Avsyuk and L. D. Dolgushin in 1954-1955 as to the normal snow supply of the ice dome of Novaya Zemlya at altitudes of over 570 m, while M. M. Yermolayev discovered in the fall of 1932, the existence on the ice shed, under fresh snow, of compact (0.903 g/cm^3) blue glacier ice of cataclastic structure, with air bubbles containing pressures of 2.23 atm. A trenching of the firn near the snow line in the autumn of 1957 showed a rapid increase in the thickness of the layer representing the annual snow increment as one moved toward the ice shed, where strata of milky white and bubble-filled firn ice occured at depths as great as 16 m.

Instrument measurements at the glacier front revealed that the ice of Shokal'skiy glacier does not move uniformly. In winter it moves somewhat more slowly than in spring and in summer, and variations in velocity are very abrupt not only in the course of the week, but even within 24 hours. The mean 24-hour displacement of the ice down the slope amounts to 27-30 cm, and may vary from 90 cm in 24 hours to 0, or may even take place in reverse direction, i. e. to recede without decreasing in bulk. Thus, the front of the glacier should move out to sea 100-110 meters annually. However, the reverse phenomenon is actually observed, and the front is receding. The forward motion of the ice does not compensate its destruction by the sea. Geodetic observations designed to determine the rate of motion of the ice at the Barrier of Doubts have not yet been fully processed, though we may expect here a rate of displacement of 70-80 meters annually.

The temperature regimen of the glacier is not without interest. Manual drilling at the Ice Shed station in November of 1957 revealed humid strata at depths of 8 and 18 m. A temperature of 0°C maintained itself at the depth of eight m until February, and until May at 15 meters, then going down by several tenths of a degree. At the Barrier of Doubts station, stable sub-zero temperatures are maintained at depths below 20 meters, and then slowly rise as depth increases, attaining zero degrees, apparently, at 55-60 m.

Evidence for high temperatures in the deeper portions of the Novaya Zemlya glacier is also to be seen in the discharge of its melt water in winter (in February and March) into the marginal valleys of the Chayev and Shokal'skiy glaciers. Another indication of heat flow from the earth's crust to the bottom layers of the glacier appears in the discovery by O. P. Chizhov of the warming of water masses in the lake on Schmidt Peninsula to depths of 10-20 m. The temperature of the water at the bottom rose from $0^{\circ}.5$-$0^{\circ}.6$ in October to $2^{\circ}.6$-$4^{\circ}.3$ in the end of June. An ice layer over 1-1/2 m thick formed on the lakes during the winter. Thus, the long-term frozen condition of the uppermost layers of the lithosphere and the sub-zero mean annual temperature are not grounds for expecting the penetration of permafrost to great depths, at least on the western shore of Novaya Zemlya.

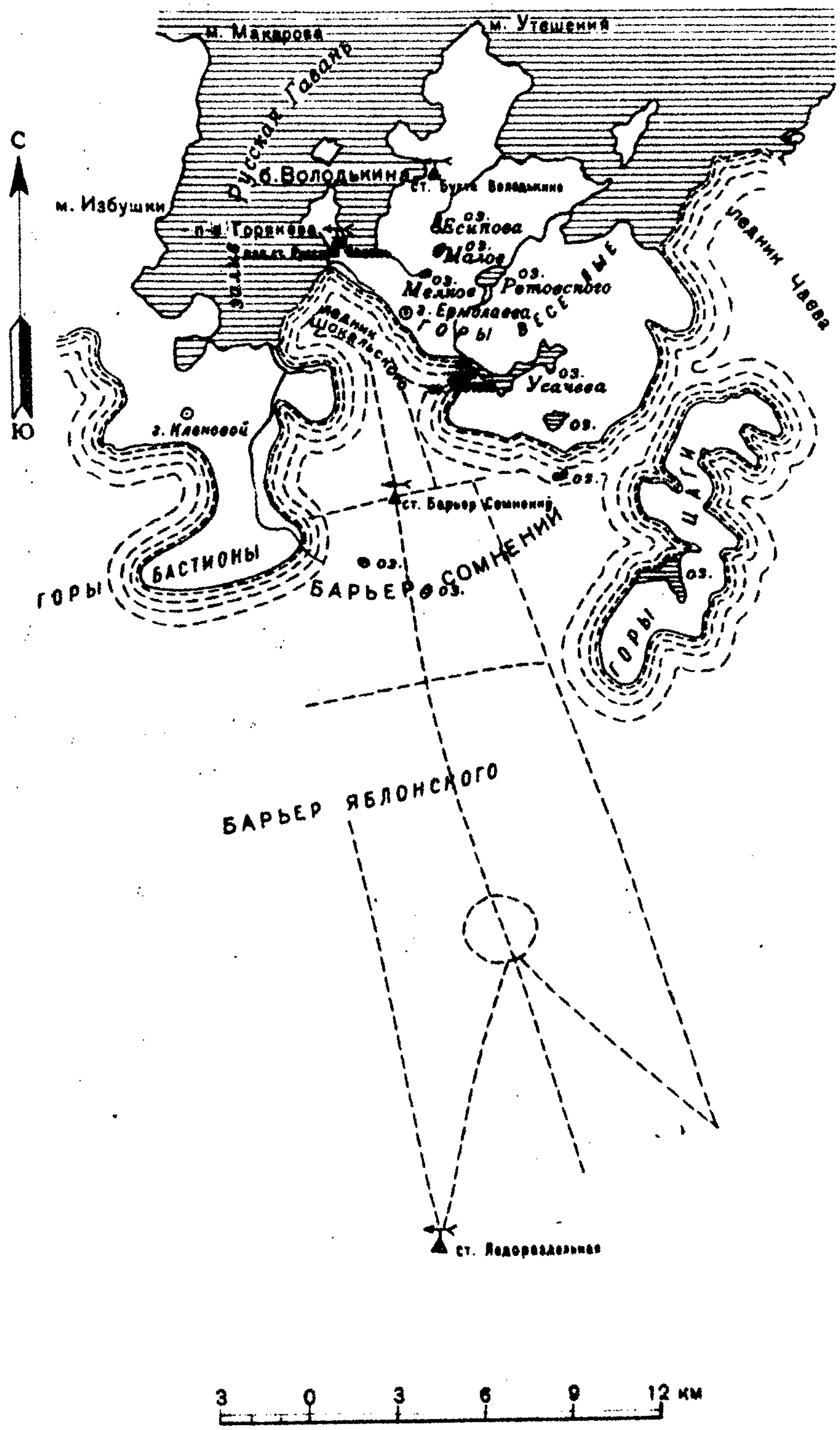
There are interesting data on the temperature of the air and of the surface of the glacier at various points. It has been found that the mean monthly temperature during the winter at the "Barrier of Doubts" station is 3-4° lower, and that at the Ice Shed, 6-8° lower than at the front. Thaw lags correspondingly by 2-3 and 4-5 weeks and stops one and 2-3 weeks earlier. The pattern of increase of total precipitation has been established, together with its intensity and frequency as the elevation of the surface of the glacier rises. Above the snow line, hoarfrost plays a considerable role in supplying the glacier. Thus, 4.9 mm of precipitation were recorded in the last 5 clear days of December 1957 at the Ice Shed station, while none occured at the Barrier of Doubts or at the glacier front.

Despite frequent winter and spring snowfalls, as a result of which the thickness of the snow cover in the feed area attained 130-170 mm (on 6/10), this thickness was somewhat above 1 meter between the Barriers, and was only 8-20 cm below the Barrier of Doubts, while approximately one third of the surface of the glacier was altogether bare. At the front, snow occured only in thin patches, covering no more than one third of the ground surface. Snow filled all the crevasses below Yermolayev Mountain, with the exception of particularly large ones on the western edge of the Barrier of Doubts. Such an uneven distribution of the snow is due to strong southerly and south-easterly winds. For orographic reasons, their velocities are particularly high somewhat north of the Barrier of Doubts. Thus for example, when mean wind velocity in February is 6.3 m/sec at the Ice Shed station and 8 m/sec at the front, it attained 11.1 m/sec at the Barrier of Doubts station. It is not surprising that winds of such force should displace an enormous amount of

snow during snow storms.

In his observations of migration of snow during snow storms, O. A. Yablonskiy found a measurable transfer of 1 g/sq. cm. min. at the surface with a wind velocity of 8 m/sec and a sharp increase as velocity increased: as high as 20 g/sq. cm min. at 30 m/sec. As for the role of snowstorms in feeding the glacier, it would seem that there is no perceptible transfer from south to north, i. e. the removal of snow from the feed zone. Snow migrates principally along the ice divides, while the quantities of snow transferred in opposite directions are roughly equal.

Novaya Zemlya
Area of IGY Glaciological Investigations



---- snow-measuring lines

$\blacktriangle$ points of stationary observations

Fig. 1

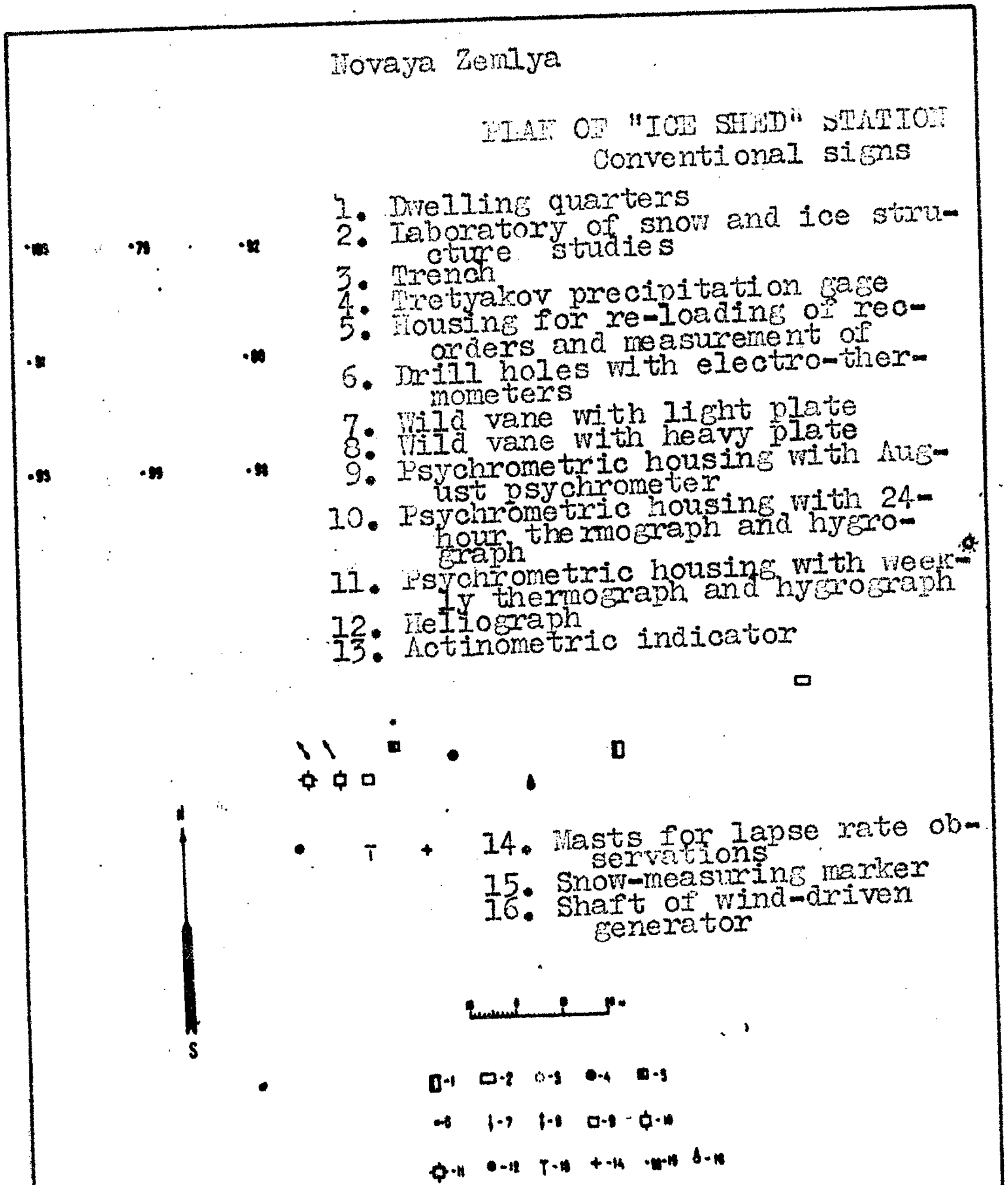

Novaya Zemlya
PLAN OF "ICE SHED" STATION
Conventional signs
1. Dwelling quarters
2. Laboratory of snow and ice structure studies
3. Trench
4. Tretyakov precipitation gage
5. Housing for re-loading of recorders and measurement of
6. Drill holes with electro-thermometers
7. Wild vane with light plate
8. Wild vane with heavy plate
9. Psychrometric housing with August psychrometer
10. Psychrometric housing with 24-hour thermograph and hygrograph
11. Psychrometric housing with weekly thermograph and hygrograph
12. Heliograph
13. Actinometric indicator
14. Masts for lapse rate observations
15. Snow-measuring marker
16. Shaft of wind-driven generator
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Fig. 2

Novaya Zemlya

PLAN OF STATION "BARRIER OF DOUBTS"

For conventional signs,
see Fig. 2

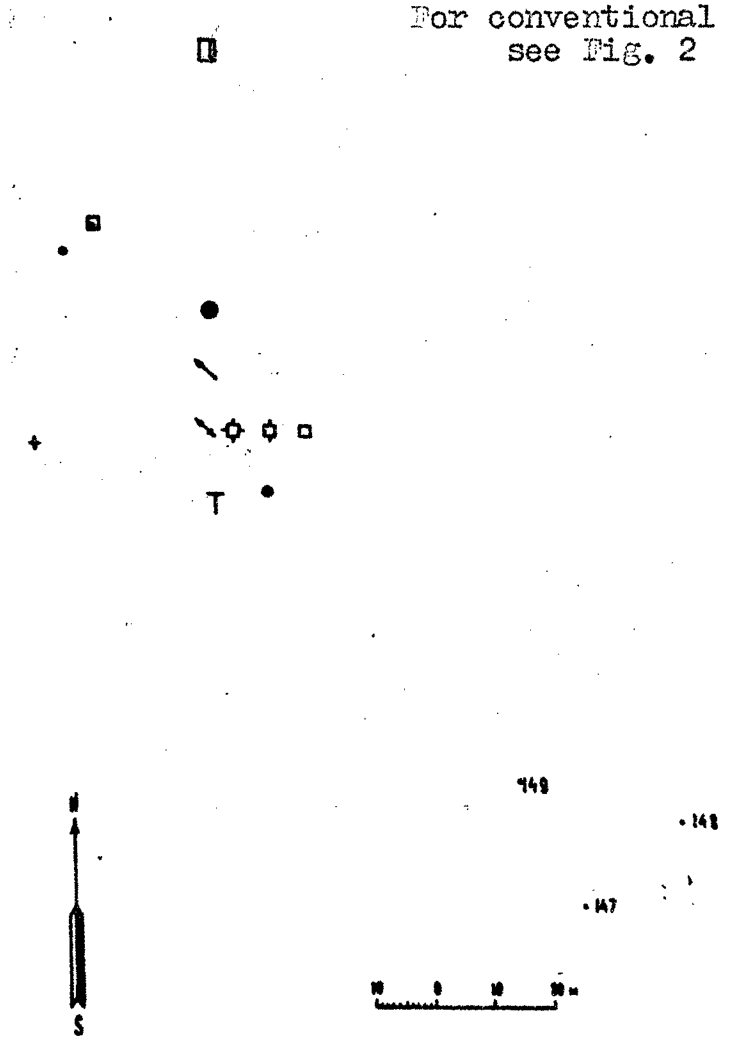

Fig. 3

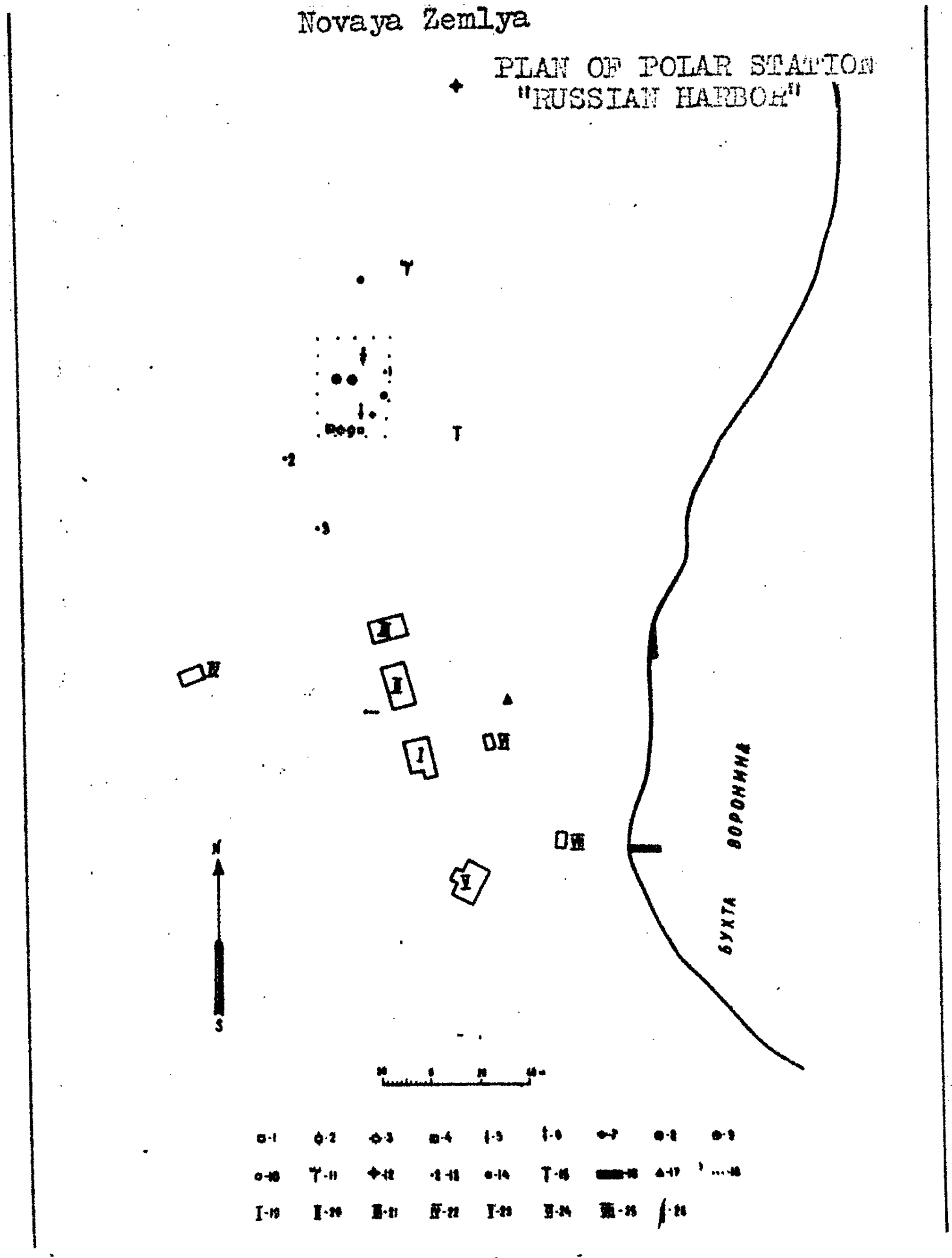

Fig. 4

1 - Psychrometric housing, 2 - 24-hour recorder housings, 3 - Weekly recorder housings, 4 - shed for recorder tape reloading, 5 - vane with light plate, 6 - vane with heavy plate, 7 - emplacement of above-ground thermometers, 8 - Tretyakov precipitation gage, 9 - rain gage with Niefer shield, 10 - post for checking vane orientation, 11 - Besson nephoscope, 12 - site of coastal ice observations, 13 - snow-measuring marker and its number, 14 - heliograph, 15 - actinometric pointer, 16 - cribwork of mareograph, 17 - elevation bench-

Fig. 4 Continued

mark, 18 - electrothermometer emplacements of 1932-1933, 19 - weather office, 20 - living quarters, 21 - stores, 22 - bath, 23 - power station, 24 - cow barn and pig stye, 25 - depot of building materials, 26 - mooring.

Novaya Zemlya

PLAN OF STATION "VOLOD'KIN BAY "
Conventional signs

1 - Psychrometric housing, 2 - Wild vane with heavy plate, 3 - Tretyakov precipitation gage, 4 - Semi-conductor electrothermometers, 5 - Bench mark, 6 - Living quarters, 7 - Power station and winter site of snow and ice laboratory, 8 - Garage, 9 - Stores, 10 - Bath, 11 - Bakery.

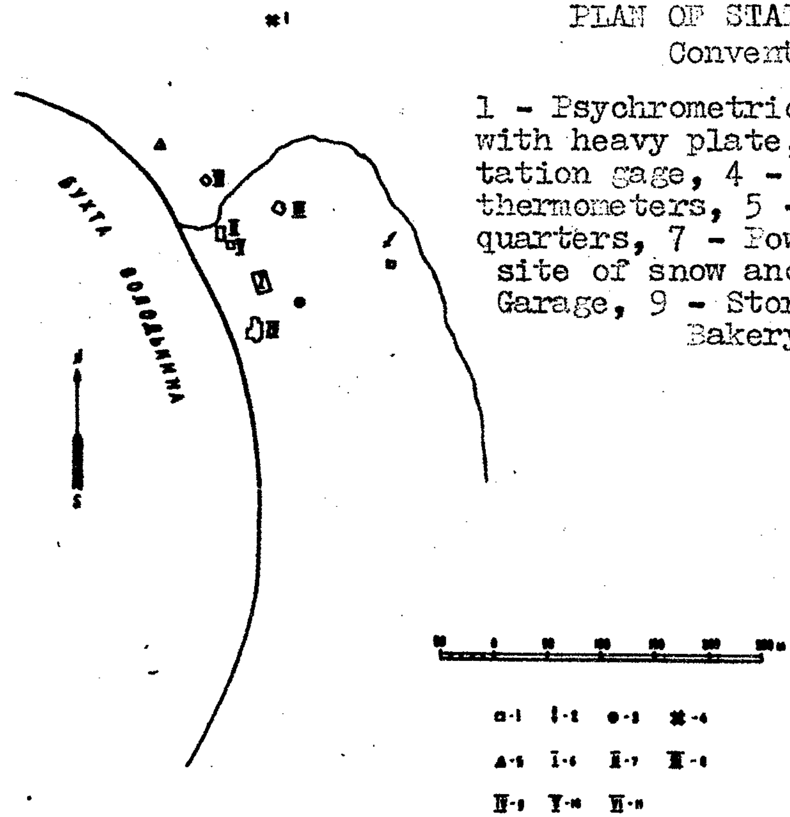

Fig. 5

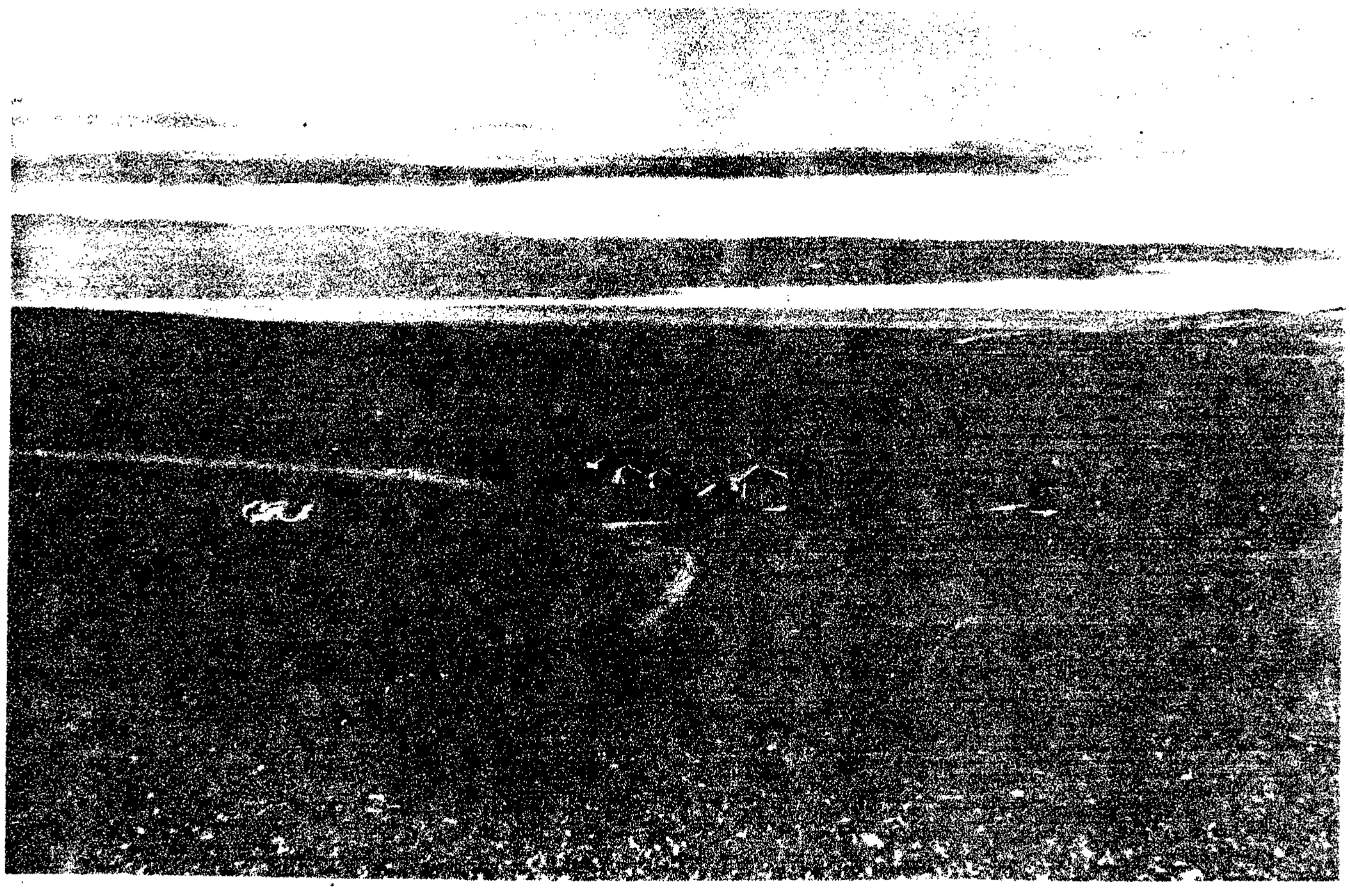

Fig. 6. Base of Novaya Zemlya glaciological expedition in Volod'kin Bay (Russian Harbor).

NOVAYA ZEMLYA IGY 1958

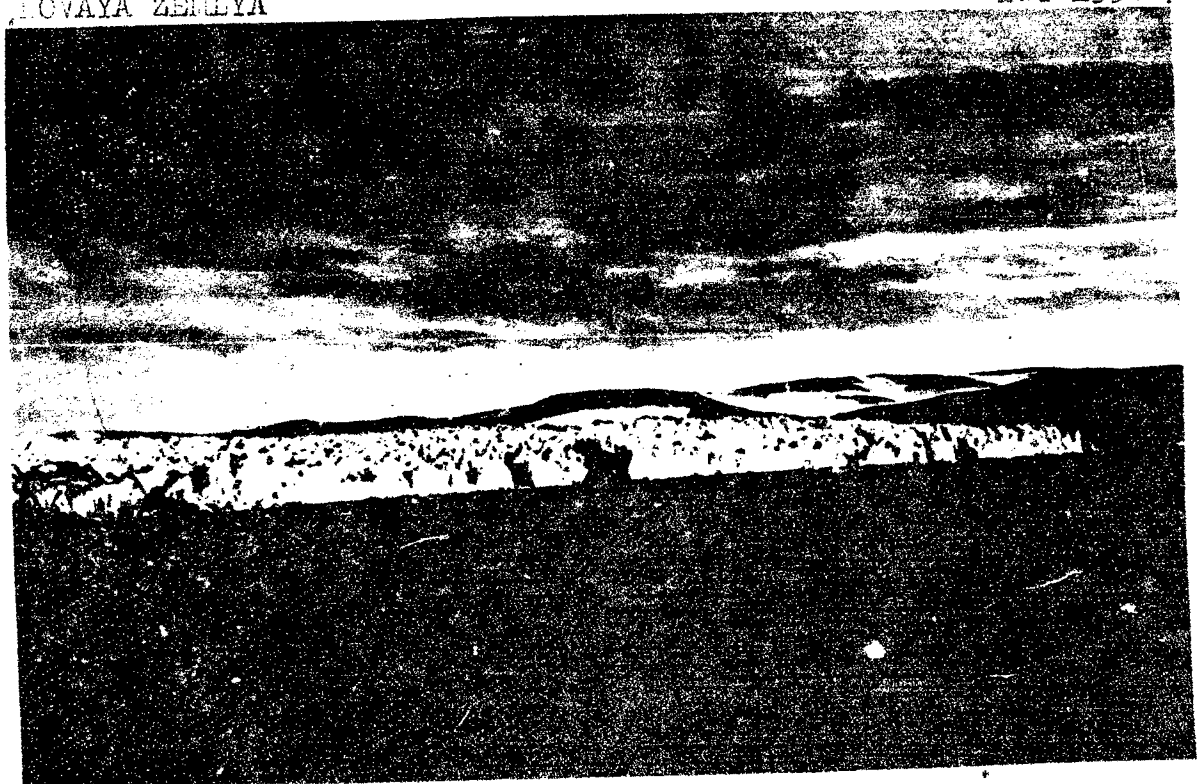

Fig. 7. Front of Shokal'skiy Glacier 22 July 1958. View from Cape Shueretskiy.

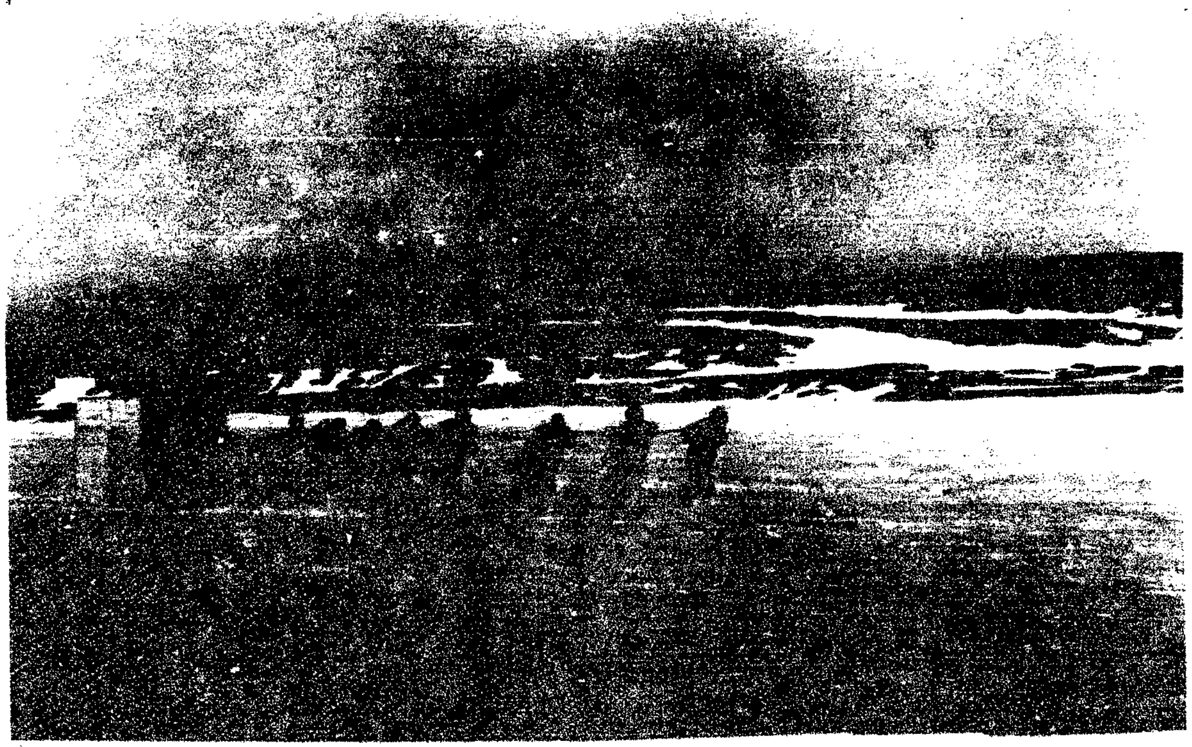

Fig. 8. Towing hydrological sleigh

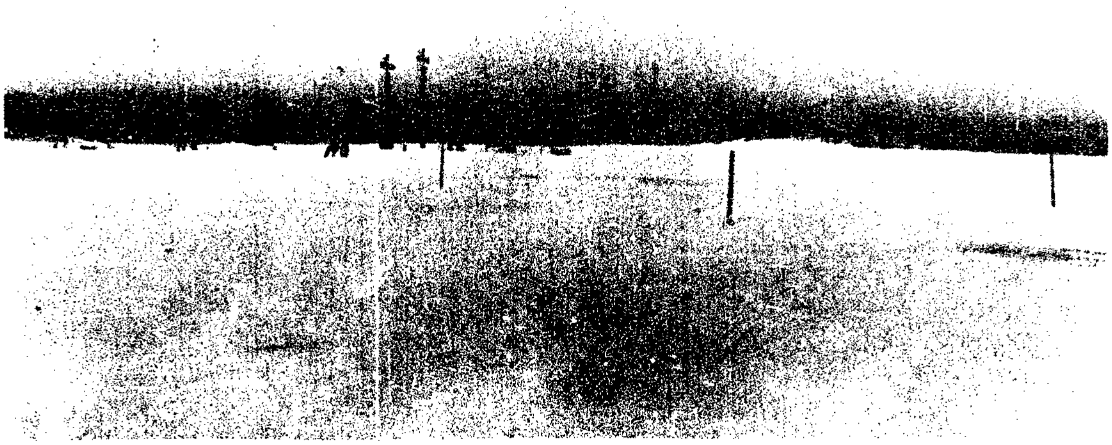

Fig. 9. Barrier of Doubts Station

Fig. 10. Ice Divide Station. At the center of the picture, only the chimney of the snow-bound house is visible. (June 1958).

Fig. 11. Measurement of velocity of ice motion at front of Shokal'skiy Glacier (June 1958).

Glaciological Investigations of the Institute of Geography of the Academy of Sciences of the USSR According to the Program of the IGY in the Polar Ural

The problem of contemporary glaciation in the Urals began attracting the attention of investigators from 1930 onward. In 1932-1933, the Committee for the 2nd Polar Year organized the Urals Glacial Expedition, which studied 16 tarn and suspended glaciers in the area of the Sablya range and the city of Narodnaya. In the years that followed, a number of new glaciers were discovered and described in various areas of the Sub-Polar and Polar Urals. It became evident that the major area of glaciation was located in the northern portion of the Polar Urals in the region of lakes B. Khadata and B. Shchuchye. Here rather large cirque-valley glaciers were located, measuring up to 1.5 - 2 kms in length.

Inasmuch as it ascribed great importance to the study of glaciers of the smaller types, the IGY committee included glaciological investigations in the Polar Urals in its program. A scientific research station of the Institute of Geography of the Academy of Sciences USSR was established in the summer of 1957 in the B. Khadata Lake region, and began stationary glaciological studies.

1. Brief Physio-Geographic Description of Area Investigated.

The area investigated is situated in the northern watershed of the Polar Urals between 67° and 68° of lat. N. A markedly dissected relief is characteristic of this portion of the Polar Urals. Maximum absolute elevations of mountains attain 1200-1300 m, while relative elevations vary within a range of 500 to 900 m.

There is a striking difference in the relief of the western and eastern portions of the Polar Urals. Plateau-like uplands are characteristic of the eastern portion, while the west, in addition to having rounded eminences, is characterized by alpine features of mountain glaciation, which include peak- and crest-like rocky eminences, cirques, deep steep-sided valleys, etc. It is precisely in this part of the mountains that we run into cirque glaciers and numerous snow glaciers.

The transverse and longitudinal valleys which divide the mountains into separate ranges and chains have steep sides and, frequently, flat bottoms. "Kurumnaki" [?] and various permafrost and solifluxion features are abundant on the slopes.

On the flat summits, features resulting from the frost-sorring of materials are widespread, and include stone

rings, bands and geometric figures.

Parts of certain stream valleys and individual basins are occupied by rather large lakes (Bol'shaya and Malaya Khodata, Bol'shoye and Maloye Shchuchye, Kuz'ty, Usvaty, and others). One encounters deep cirque lakes.

The climate of the area is continental, featuring a long harsh winter and a short cool summer. Westerly winds prevail, and attain at times velocities of 25-30 m/sec (with gusts of 40-45 m/sec). The annual precipitation recorded by the weather station of the B. Khodata Lake for the period from 1 September 1957 to 1 September 1958 exceeded 850 mm. The most intensive precipitation was observed in the summer and autumn months (June - October: 530 mm). The snow cover was distributed unevenly over the various features of relief. Maximum snow accumulation is found to occur in valleys and cirques.

As a result of the abundance of solid precipitation and the prevalence of strong winds of constant direction, favorable conditions are created for the accumulation of large snow drifts on the leeward slopes of open areas, which generate snow glaciers and small cirque glaciers. As a rule, glaciers are situated in cirques of northeastern exposure in the western upland zone of the Polar Urals.

2. Description of Subjects of Investigation.

The main features studied by the Polar Urals Glaciological Expedition are the glacier named after the Institute of Geography of the Academy of Sciences USSR, the Obruchev glacier, and the glacier of the MGU (Main Geodetic Office). These are the largest glaciers of the Polar Urals. They are briefly described below.

The Glacier of the Institute of Geography of the Acad. Sci. USSR is situated on the eastern slope of Khar-Naurdi-Key Mountain, at the headwaters of a stream which flows into the lake of B. Khadata. It has a length of 1.8 kms and an area of 1.4 sq. kms. The glacier occupies an asymmetric cirque, open on its eastern end, consisting of two morphologically distinct portions. The southern portion of the glacier, which covers the lower rim of the cirque, is situated on a completely open slope, and rises steeply to its very crest. It is a typical leaning (sloping) glacier, of a type widespread in the Polar Urals. The northern and larger portion of the glacier has a well-developed lobe, and belongs to the cirque-valley type of glacier. The glacier consists of banded ice, which forms a well-defined ogive pattern on the surface. The western and northern rims of the cirque rises above the surface of the glacier as nearly vertical 200-meter walls. The lobe of the glacier is rimmed by the

accumulations of the lateral moraines, attaining 30 m in height, which merge at the end of the lobe to form a large terminal moraine up to 400 m in width. The morainic eminences always contain cores of ice, which are covered with a sheath of erosional debris. The erosional debris, which originate on the slopes of the cirque, are largely absorbed by a system of deep lateral crevasses which ring the glacier. At the transition point between the firn basin and the lobe, there are several glacial sinks up to 30 m in depth. The run off of melt water from the surface of the glacier takes place through a system of narrow gulleys which, upon merging at the terminus of the glacier, form a shallow lake. The undercut of the lake is 830 m. Having opened a route for itself under the terminal moraine in the form of an ice cavern, the melt water issues from under the outer edge of the moraine as a full-size stream, milky-white in color from glacial sediment.

The Obruchev glacier is situated six kms to the west of B. Khadata Lake in a deep steep-sided cirque of eastern exposure. The length of the glacier is 1.2 kms, and its area is 0.36 sq. kms. The glacier is formed of banded ice, the lobe is poorly defined, and has a grade of up to 20°. Its terminus is situated at an absolute elevation of 500 m. This is a typical representative of the cirque glacier type. The central part of the glacier contains deep crevasses and sinks, and the surface bears large boulders and rock fragments fallen from the rims of the cirque. The terminus of the glacier and its northern part are covered with a large morainic accumulation, whose core consists of ice. The outer edge of the moraine drops steeply to a small field and a shallow lake, subdivided by the hummocks of an ancient moraine. The glacial stream from the margin of the glacier flows between the humps of the terminal moraine and enters the outlet lake.

The MGU glacier lies five kms to the west of the southeastern end of lake M. Shchuchye. It occupies a steep-sided cirque elongate in outline, whose exposure varies from northeastern to eastern, and then to northeastern again. The length of the glacier is 2.2 kms, and its area equals 1.15 sq. kms. The glacier has a well-defined firn basin and lobal portion. The firn basin rises steeply almost to the rim of the plateau, and contains deep transverse and marginal crevasses. At the point where the firn basin joins the lobal portion there are several sinks up to 35 m in depth. The terminal portion of the lobe is markedly constricted, and slopes down to an absolute elevation of 650 m. Along the margins of the lobe rise the high eminences of the

lateral moraines (attaining 50 m in height), which become a large terminal moraine at the end of the lobe. The glacier is formed of banded ice, which forms a very well defined pattern of ogives on its surface. The terminal portion of the glacier is loaded with a considerable amount of debris, and "degradation cones and ridges" occur. The runoff of melt water takes place through gulleys which deepen gradually and disappear at the terminus of the glacier in a deep ice cavern. The glacial stream reappears from below the outer edge of the terminal moraine, flows across the "zandrovaya" [?] platform and flows into a shallow outlet lake.

3. Description of Glaciological Investigations in the Polar Urals.

The main subjects of glaciological investigations, as pointed out earlier, are the Institute of Geography, Obruchev and MGU glaciers. In addition, observations are being conducted at the base station on B. Khadata lake. On the Institute of Geography glacier and at the base station, stationary observations are being made throughout the year. On the Obruchev and MGU glaciers, stationary observations are conducted in the summer, and episodic observations take place at other times of the year. The expedition also conducts mobile observations with a view toward studying the glaciers and gaining a fuller knowledge of the conditions of contemporary glaciation in the Polar Urals.

Observations on the Institute of Geography glacier began in spring of 1958. A permanently operating stationary observation point has been established to work in accordance with the IGY program of glaciological studies.

The following types of observations are being conducted on the glacier and on the adjacent plateau.

1. General weather observations, whose purpose it is to study weather conditions on the glacier and the adjacent plateau. Weather platforms have been set up in the lobar portion of the glacier (abs. elev. 880 m), and on the lower plateau (abs. elev. 740 m) 1 km SE of the glacier. The weather platforms are equipped with: psychrometric housings, housings containing 24-hour recorders (thermograph and hygrograph), Tretyakov precipitation gages, a Wild vane, a heliograph, snow-measuring rods. 4-interval observations are made of air and soil temperature, pressure, precipitation, duration of solar illumination, wind direction and velocity, cloud cover, visibility and atmospheric phenomena. In winter time, 4-interval weather observations are conducted only on the plateau, while 24-hour recorders, serviced daily, are in operation on the glacier. During the ablation

period, weather observations follow the same schedule on the glacier and on the plateau.

2. Actinometric observations bear on direct, total, scattered and reflected radiation and on the thermal balance. The weather platforms on the glacier and on the plateau are equipped with actinometric apparatus including albedometers and balance gages. During the ablation period, actinometric observations on the glacier followed an eight-interval schedule or took place as hourly series, depending on the weather. In winter time, actinometric observations are performed mainly on the plateau (eight intervals), while episodic albedo surveys are conducted on the glacier.

3. Lapse rate observations are performed in conjunction with actinometric and balance observations in order to study heat exchange between the air and the underlying surface (ice or ground), and the components of the heat balance of the glacier.

During the ablation period, lapse rate observations on the weather platform of the glacier were conducted at 4 intervals and in series at 2-hour intervals depending on the type of weather at levels of 2.0, 1.0, 0.5 and 0.25 m. The observations involved the use of Assman psychrometers and Fuss hand anemometers. In winter time, 4-interval lapse rate observations at the same level are conducted on the weather platform on the plateau to study heat exchange between the snow surface and the air.

4. Temperature observations on the glacier were begun in January of 1959 in three 25-meter drill holes, perforated in the firn, central and lobar poertions of the glacier. Electrical resistance thermometers have been set up in the drill holes in the ice at depths of 0.5, 1.0, 2.0, 3.0, 5.0, 10, 15, 20 and 25 m. In the drill hole of the lobar portion of the glacier, thermometers have also been set in the snow layer at intervals of 0.5 m and in the air on a gradient mast at heights of 0.05, 0.1, 0.25, 0.5, 1.0 and 2.0 m. Remote control switches have been installed over the drill hole, with a lead out toward the living quarters (1.5 - 2 kms) where a special control device, a resistance bridge and a galvanometer allow the determination of temperatures of the ice (once in 24 hours), of the snow layer and the air (4 times in 24 hours). As a check on the correctness of the temperature readings from the drill holes, platinum thermometers have been installed, to be used in determining the temperature of the ice two or three times a month. In the beginning of winter, temperature soundings were made to a depth of 10 m in various portions of the glacier.

A 6-meter gradient mast has been set up on the weather platform on the plateau, and is used to determine temperature gradients in the air at 1 m intervals, in the snow at 0.25 m intervals, and in the ground to a depth of 0.5 m.

5. Hydrological observations on the glacier have been performed during the ablation period to investigate the attrition phase of the equilibrium of matter in the glacier. The observations consist of daily water level measurements of the glacier stream, of water discharge measurements, observations of surface runoff on a runoff platform, and the measurement of the extent of ablation with the aid of ablation-measuring rods.

At 250 m from the outer edge of the terminal moraine on the glacier stream a water observation point has been set up, equipped with a "Valday" level recorder. Levels were determined twice in 24-hours, and water discharge was measured periodically in the stream bed for various levels. To measure runoff from the surface of the glacier, a runoff platform measuring 40 x 20 m was set up, and used for several twenty-four hour series of observations. Observations on the runoff platform were performed simultaneously with lapse rate and actinometric observations, thereby allowing a calculation of runoff from the surface of the glacier as it relates to the amount of inflowing heat.

Throughout the ablation period, daily observations of the melting of the ice were kept up on the surface of the glacier, using ablation-measuring rods. In all, 5 rod traverses have been laid out, using a total number of 42 rods. The rods are made of bamboo and are set in the ice at a depth of 1.0 - 1.5 m. On the transverse lines, the rods are set at 50 m intervals, and at intervals of 100-150 m on the longitudinal traverse.

6. Observations of the snow cover on the glacier and adjacent portions of the plateau are conducted throughout the entire period of snow accumulation and thaw. Observations bear on the regimen, dynamics, morphology, structure and microstructure of the ice. One of the aims of the study of the snow cover is an analysis of the attrition phase of the equilibrium of matter in the glacier. Rod alignments are used to observe snow accumulation. All Rods are checked at 10-day intervals (in the beginning of winter, the total number of rods was increased to 58). In addition, the glacier and plateau weather platforms are used daily for observations of variations in the height and morphology of the snow cover. On the glacier and on the plateau trenching is performed every 10 days, and studies are made of the compactness, stratigraphy, structure and temperature of various layers within the

snow cover. These data are used to compile stratigraphic diagrams of the diagenesis of the snow cover. Observations are conducted of the transfer of snow by snow storms on the glacier and adjacent uplands.

Particular attention is being devoted to the study of the structure of the firn layer and to the analysis of processes and types of ice-formation. For this purpose, the firn layer has been trenched, and determinations have been made of the extent of ice accretion during the beginning of the snow thaw on the glacier.

7. Observations of the velocity of motion of the upper ice layers are carried out along rod alignments set up on the glacier in the summer of 1958. The end-points of the alignments are marked on rocks and on the plateau for reference. A photo-theodolite survey of the glacier was performed in the summer of 1958. Its repetition in 1959 will make it possible to show the extent of displacement of the rods as a result of glacier motion.

In accordance with the IGY program, the types of observations enumerated were not the only ones on the surface of the glacier. Observations were also made of the manner of displacement of erosional débris on the surface of the ice, snow slides, boulder avalanches, denudation of snow from portions of the glacier and from slopes, the rate of the filtration of water in the snow layer, and the rate of percolation, using the dye method. Rock samples have been collected to determine the lithological composition of the moraines, and observations have been made of the erosion of moraines by glacial streams, of the formation of moraines, and studies have been made of specific crevasses and sinks on the glacier. Samples of ice from various levels were gathered during drilling for an analysis of its microstructure and hydrostatic weighing. A plane table and phototheodolite survey was performed in the summer of 1958, and a plan of the glacier was prepared at a scale of 1:5000.

On the Obruchev glacier, observations were conducted during the summer and fall season of 1958 (June - August). At the center of the glacier (abs. elev. 670 m) and on the ancient moraine in front of the glacier (elevation 520 m) weather platforms were set up. These were used for general weather (4-interval), actinometric (8-interval) and lapse rate (4-interval) observations. Balance and lapse rate observations on the glacier were also conducted in series at hour intervals, depending on the type of weather. The weather platforms have been equipped with psychrometric units, precipitation gages, Tretyakov wind gages, a heliograph, and lapse rate and actinometric apparatus.

Ablation observations were also conducted on the glacier using three rod alignments, with the rods spaced at 20 m. Water level and discharge were measured in the glacier stream. A snow survey, aiming at determining the snow reserve of the glacier, was performed at the end of winter in 1958. A phototheodolite survey was performed in the summer of 1958, and a plan of the glacier was compiled at 1:5000.

Observations were made during the summer season on both the Obruchev and MGU glaciers. Weather (4-interval), actinometric (8-interval), and lapse rate (4-interval) observations were included, along with observations of ablation and runoff. Weather platforms were set up on the glaciers and were equipped with lapse rate and actinometric apparatus, precipitation gages and wind gages. Ablation-measuring traverses were laid out. Runoff platforms were set up, to allow series of 24-hour observations in conjunction with lapse rate observations. Water levels and discharge were measured in the glacier streams.

In addition to the investigations on the glaciers, observations were also organized on the weather platform of the base station of B. Khadata Lake. The weather station is located on the outwash of a stream running through the station at 500 m to the east of the Bol'shaya Khadata Lake (absolute elevation of the weather platform: 232 m). The weather platform is equipped with the following: a psychrometric unit, a housing for recorders, vanes with heavy and light-weight plates, a heliograph, a Tretyakov precipitation gage, a total-precipitation gage, a pluviograph, lapse rate and actinometric apparatus, IMC. Weather observations are conducted at 4 intervals, actinometric observations, at eight intervals, and lapse rate observations, at four intervals. Observations bear on the snow cover, and snow storm measurements are taken. On the B. Khadata river, at 200 m from its source, a water observation station has been set up, and is used for daily measurements of the water level and periodic discharge measurements.

To analyze certain metereological features peculiar to the B. Khadata river valley and adjacent tablelands, observations during the winter-summer period of 1957-1958 were organized at micro-climatic points, MK-1, situated on a plateau at 1.5 km north of the base station (abs. elev. 680 m) and MK-2, 13 km downstream on the B. Khadata river (abs. elev. 180 m).

The performance of a program of weather observations in the valley, on the table and on the glaciers ensures the possibility of an analysis of the climatic conditions attendant on glaciation in that part of the Polar Urals.

To find general regularities in the distribution of the snow cover, a snow-measurement survey was conducted in the area of the Polar Urals under study in April-May 1958. It encompassed the B. Khadata river and its tributaries, adjacent table lands, and cirques. A traveling snow survey was performed on the eastern slope of the Polar Urals. A study of the distribution of the snow cover is of great importance in understanding the causes and conditions of the formation of glaciers in the Polar Urals.

Field trips were organized in the summer of 1958 to investigate and gain knowledge of a number of glaciers in the Polar Urals. Studies and descriptions were made of glaciers situated near the base station, as well as in the Oche-Nyrd range (60 kms to the north of B. Khadata Lake), where the northernmost focus of glaciation in the Urals is located.

4. Expedition's Living and Working Quarters, Communications and Transportation Facilities.

At the central base located on the shore of lake B. Khadata, 5 log and plank houses were built. These varied in usable space from 25 to 65 sq. m. They contained living quarters for the expedition staff, the weather station, and workshops. The base includes a mess hall, a bath house, stores, a garage and a power plant.

Small heated plank houses have been built near the Institute of Geography and Obruchev glaciers. Other features under study are made accessible through the use of small mobile houses on sleds and heated tents.

The expedition has been provided with the following means of transportation: two S-80 tractors, two DG-54 tractors, one GAZ-17 all-surface truck, and a GAZ-63 car.

In addition, helicopters, horses and reindeer are rented, when needed, from local organizations.

Communications within the investigated area are effected by means of portable radio and telephone units. Radio contact over long distances is maintained through a transmitter-receiver at the central base.

Fig. 2. General view of glaciological station of the Institute of Geography of the Acad Sci USSR

Fig. 3. A helicopter at the glaciological station.

A Brief Description of the Objects of Investigation and A List of Activities of the Elbruz Expedition

The following field parties participated in the investigations of the Elbruz Expedition:

I. Phototheodolite party.
II. Climatological party.
III. Hydrological party.
IV. Southern Glacio-Geomorphological party.
V. Northern Glacio-Geomorphological party.
VI. Glaciological party.
VII. Thermo-physical party.
VIII. Paleo-glaciological party.
IX. Winter party at "Glacial Base".

Preparatory operations at Terskol (2200 m) included the construction of the Glaciological Station of the Main Geodetic Office (two buildings). At the same time, allocation for temporary use was made of the quarters of Glacial Base at 3700 m.

1. Information on activities of the photo-theodolite party under IGY program.

1. Area of investigations. Major concerns.

Photo-theodolite operations in surveying glaciation on Mt. Elbruz were conducted on the southern, eastern and northeastern slopes of the Elbruz.

Phototheodolite operations on Mt. Elbruz are concerned with defining the spatial extension of glaciers and snow glaciers. This year's work included the following:

a) complete surveys of glaciation on the Elbruz (eastern and northeastern slopes) at a scale of 1:10,000, with a view toward recording the extension of all glaciation on the Elbruz during the IGY period;

b) re-surveys of specific Elbruz glaciers at scales of 1:2000 - 1:5000. These surveys aim at a study of annual fluctuations of the spatial extent of the glaciers.

The following areas have been covered by the survey at 1:10,000 during the IGY period:

90 sq. kms on the east, and
50 sq. kms on the northeast.

The glaciers B. Azau, Tereskol and Irik have been surveyed at larger scales.

In order to gather fully valid cartographic materials from the data of the photo-theodolite survey, considerable geodetic work was performed in 1958 in order to tie in individual photographic stations into a single partial system of coordinates.

2. Equipment.

Photo-theodolite survey field equipment includes:

a) an FTI (TAN model) photo-theodolite camera, with applied frame format of 13 x 18 sq. cm., a focal length of fK = 193 mm (manufactured in the USSR);

b) a TB-1 optical theodolite with an optical micrometer interval value of 1" (manufactured in the USSR);

c) a 2-x meter Zeiss range-finder rod.

The processing of the materials of the photo-theodolite survey is taking place on the large Zeiss stereoautograph No. 11295.

3. Enumeration of principal activities.

The following kinds of operations have been included and completed at the present time under the program of the laboratory processing of the photo-theodolite survey materials:

a) geodetic computations;

b) compilation of maps at the scale of 1:10,000 for the southern and northern slopes of Mt. Elbrüz;

c) compilation of maps of glaciers B. Azau at 1:5000 and Ullumalyenderku at 1:2500;

d) compilation of photographic map from aerial photographs of 1957 flight;

e) completion of work on content and conventional signs of glacier maps;

f) processing of materials of photo-theodolite resurveys of glaciers B. Azau, M. Azau, Garbashi and Terskol;

g) study of the dynamics of the B. Azau glacier over a period of 47 years, by using materials of the Burmeyster surveys of 1911.

2. Information on activities of climatological party of Elbruz Expedition.

1. The purpose of the work is to investigate the components of the thermal balance of the glaciers on the southern slope of Elbruž.

2. Area studied. The main observation area was situated on an open even tableland measuring roughly 1.5 x 0.8 kms, at an altitude of 3750 m above sea level. The surface of the plateau has a slight grade from west to east (1-3°). The underlying surface (during the summer season) consists of firnized ice a few meters in thickness, underlaind by ice.

Transportable platforms, on which observations were conducted over periods of 1 - 2 days, were set up a) on the lobe of Garbashi glacier, 200 m from base camp, b) on the SE

slope of the glacier, 60 m below the base platform, and c) at "Shelter 11", on a steep incline of the glacier at an elevation of 4200 m above sea level.

3. Content of investigations. The basic subject under investigation, "the thermal balance of glaciers on the southern slope of Elbruz", involves studies of the following:

a) the radiation balance,

b) turbulent heat exchange between the ground-level air layer and the underlying surface,

c) the evaporation - condensation process on the surface of the glacier,

d) direct measruements of ablation and accumulation in the summer season,

e) the moisture content of the snow (liquid phase) in the upper layer, and

f) measurement of heat flow in the upper snow layer (down to 40 cm).

4. Observation program, equipment.

The following observations were conducted on the base platform:

a) measurement of the components of the radiation balance (total, scattered, reflected solar radiation, long-wave radiation balance) by means of a thermoelectric actinometer, a stationary albedometer, a balance gage, and an indicating galvanometer of type GSA-1. The duration of sunlight is recorded by means of a Campbell-Stokes heliograph. Observations were conducted hourly from 7 to 19 hours.

b) Lapse rate observations (measurements of atmospheric temperature and humidity, wind velocity) with the aid of suction psychrometers and manual anemometers. Each series of observations conducted, like the actinometric observations, at hourly intervals between 7 and 19 hours, included 8 measurements of temperature and humidity, and 2 10-minute anemometer observations. 24-hour observations at hour intervals were conducted non-periodically.

c) Measurements of evaporation (condensation) from the surface of the snow were performed with the aid of evaporators, made of organic glass (dimensions 12 x 12 x 10 cm).

d) Direct measurements of ablation (accumulation) on the surface of the plateau with the aid of 18 graduated rods, set along two mutually perpendicular profiles (S-N and W-E). At specific points in the profile, measurements were made every five days of the compactness of the upper snow layer, using a snow weigher.

e) Tests to determine the moisture content of the snow (liquid phase) were conducted sporadically (depending on weather conditions) by the calorimetric method. As a

rule, humidity content was determined for the upper snow layer (down to 15-20 cm) during the daily thaw period (from 9-10 to 18 hours).

f) Several experiments were also made in measuring heat flow directly in the upper snow layer, using thermo-transitometers, prepared in the laboratory of Professor V. A. Savelyev.

g) In addition to the observations listed for the base platform, additional observations were conducted over limited periods. These included measurements of the temperature of the surface of the snow at night time using a thermo-"pauk [?].

h) Recordings of atmospheric temperature and humidity at an elevation of 0.5 m.

i) Measurement of the temperature in the snow layer down to 1 m by means of platinum thermometers.

j) Measurement of temperature down to a depth of 1 m by means of a humid thermometer.

Observations followed a simplified schedule on the transportable platforms:

a) measurement of atmospheric temperature and humidity, wind velocity at elevations of 0.5 and 2.0 m from the surface with the aid of psychrometers and anemometers;

b) measurement of total, scattered and reflected radiation by means of a field albedometer.

5. List of instruments used in the observations:

1) thermoelectric actinometer,
2) stationary albedometer,
3) field albedometer,
4) balance gage,
5) GSA-1 model galvanometer,
6) suction psychrometers,
7) manual anemometers,
8) Campbell-Stokes heliograph,
9) 24-hour thermograph,
10) 24-hour hygrograph,
11) minimum thermometer,
12) expansion thermometer,
13) platinum resistance thermometers with MVU-49 bridge,
14) standard scales T-1000,
15) snow weigher.

Non-standard equipment:

1) thermotransitometers,
2) evaporators,
3) thermo-"pauk" [?]
4) rods.

3. Information on activities of the hydrological party of the IGY Elbruz expedition.

Description of area worked.

The operations of the hydrological party of the IGY Elbruz expedition were organized on the southern slope of the Elbruz, on the Garabashi glacier and on the stream of the same name.

The party consisted of four persons.

The work took place at two points: at a hydrometric station set up on the Garabashi river below the confluence of the streams forming it, and on a runoff area, outlined on the lobe of the Garabashi glacier.

The lobe of the glacier, on which observations were conducted, is very suited to such work, is easily accessible, and lacks crevasses of any great size and ice falls. The grade of the lobe of the glacier is about 15° on the average. In spots, the lobe is snow-covered (this applies to about 70 percent of the total surface of the lobe in the beginning of summer, and to no more than 10 percent at the end).

There is well-developed superficial hydrographic system on the surface of the glacier. It is formed of streams, troughs, depressions, etc., which represent a definite regulating volume.

All the surface runoff from the glacier merges into three large streams which then join to form the Garabashi river.

The river is a typical mountain stream: the bed is poorly defined and contains boulders, waterfalls, and very steep and uneven grades. The behavior of the river is likewise typical of streams fed by snow and glaciers: it has well-defined diurnal patterns of water discharge and suspension content, with well-marked lows at night and in cold weather.

In its upper part, the valley of the Garabashi R. was quite recently (map of 1878) occupied by the lobe of the glacier. It is V-shaped and has steep rocky or morainic sides. The valley is overloaded with fragmented materials, and for this reason may have dangerous landslides. Evidence of slides on a considerable scale (the last of which was observed in 1947) are easily seen where the Garabashi R. enters the valley of the Azau river.

The valley is passable only with difficulty in its lower and middle portions.

The purpose for which a hydrological party was organized within the Elbruz expedition was that of studying the regimen of a mountain stream in the periglacial zone, and the genesis of surface runoff on a glacial lobe.

The investigations were pursued in the two directions mentioned earlier: on the one hand, observations of the level and discharge pattern and the diurnal turbidity pattern at the hydrometric station and, on the other, observations at the runoff area on the lobe of the glacier with simultaneous attention to ablation by means of ablation-measuring rods set up along a transverse profile cutting across the lobe of the glacier.

Distribution of all types of hydrological observations.

a) The hydrometric station, equipped with a wooden bridge, is situated 200 m downstream from the confluence of the three streams that go to form the Garabashi R., at a point where the stream is not divided into arms and has a relatively stable bed.

b) A water-measuring station has been hollowed out in the rock 50 m above the hydrometric dam, and consists of two rods, a main wooden one, and a spare one.

c) An automatic level recorder of the "Valday" type has been set up 100 m below the hydrometric dam in a specially-designed wooden trough with a bridge.

d) The runoff area measures 10 x 10 m is bordered by a double ditch and is situated on the glacier ice of the lobe of the Garabashi glacier, 100 m from its eastern edge, in an portion having a uniform incline of 10 - 15° and lacking crevasses. A control rod for the observation of ablation and a mast for an Assman psychrometer have been installed near the area.

e) The ablation rod profile extends across the lobe of the Garabashi glacier from its eastern to its western margin. The profile is marked with 8 rods 1.5 m in length, originally set in the ice at depths of 1 m, and graduated in 5 cm intervals.

Content of hydrological observations by category.

a) Water-measurement observations take place at six times: at 8, 10, 12, 15, 17 and 20 hours. The observations bear on level and on water and atmospheric temperatures.

b) Samples for the determination of turbidity are taken at 8, 15 and 20 hours. The sample volume was three liters at the beginning, then one liter. The samples are allowed to settle for 24 hours, and are then filtered through paper filters.

c) The tape is changed once in 24 hours at 8:00 hours in the "Valday" level recorder. Additional check in the daytime at 16 hours.

d) At the hydrometric station, water discharge is read from once to three times in 24 hours (24-hour series). This was done daily at first, then once every 2 - 3 days

after the form of the curve = / / [sic] had been ascertained. In all, 25 discharges have been measured.

e) At the runoff area, series of water discharge measurements are performed hourly by the volumetric method with simultaneous measurement of atmospheric temperature and humidity at an elevation of 2 m above the surface of the ice by means of an Assman psychrometer. Diurnal observations were usually conducted until the surface runoff stopped or dropped sharply.

f) Observations of ablation-measuring rod took place on days at which work was taking place at the runoff area, prior to the beginning and after the end of observations of surface runoff.

4. Information on activities of the southern glaciogeomorphological party.

The party consisted of three persons.

1. Description of area worked.

The area investigated is situated within the confines of the southern slope of Mt. Elbruz. Five glaciers and periglacial valleys were studied during the IGY period: Bol'shoy Azau, Malyy Azau, Garabashi, Terskol and Irik. Operations ranged at elevations of 2 to 5.5 thousand meters.

All the glaciers and periglacial valleys mentioned above are similar to one another from the glacio-geomorphological point of view, and share a common pattern of development. At the present time, they are all in a phase of retreat, which began in the fifties of the last century.

The most distinctive features of the area herein described (geomorphologically) are:

a) the presence of glacial relief forms;

b) the great development and wide distribution of nival processes and nival relief forms;

c) the wide distribution of avalanche activity;

d) landslides.

Glacial relief forms are represented mainly by the accumulations of riparian moraines of the last glaciation, fluvio-glacial terracing and terminal moraines (B. Azau valley). Traces of earlier glaciations in the area investigated have hardly been preserved at all. Among them, however, should be mentioned the trough-like nature of the valleys in general, and trough edges preserved at certain locations, in particular.

In addition to glacial activity, nival processes have had an important role in forming the relief and friable deposits of the area, and specifically, the role of snow has

been considerable. One of the forms in which the activity of the snow assumes are avalanches, which create distinctive features of relief: avalanche troughs and channels, erosional fans, which frequently cover moraines and fluvio-glacial terraces. Avalanches have a very wide distribution in the area we are describing.

Another very characteristic feature of our area are landslides. The parent materials of landslides are often morainic deposits, and this has frequently confused observers, who have mistaken solifluxion lobes and ridges for terminal moraines.

A very interesting feature of glaciation in the area described is the occurence, in the ice on Mt. Elbruz, of young Holocene lava outpourings. The problem of the relationship of these lavas and moraines is a fundamental one in attempting to find out the history of the last glaciation.

A typical feature of glaciers in the southern area of glaciation on Mt. Elbruz is the occurence of dead ice deposits (these are most abundant in the upper part of the B. Azau valley). Dead ice deposits represent one of the phases of the existence of a glacier. They may be termed "dead" it would seem only in an arbitrary sense.

2. Purpose of the investigations.

The main purpose of the investigations is to gain knowledge of the dynamics of the glaciers and of their geological and geomorphological activity, as well as an understanding of the basic geomorphological processes in the periglacial zone.

3. Major topics studied:

a) The dynamics of the glaciers over the past 100 years.

b) The geological and geomorphological activity of the glaciers.

c) The relationship of Holocene lavas to the moraines of the last glaciation.

d) Major exogenous processes in the periglacial zone.

4. Content of observations:

a) Compilation of glacio-geomorphological map at a scale of 1:10,000.

b) Installation of markers at glacial termini.

5. Information on activities of northern glacio-geomorphological party

Purpose of work. Investigation of northern and western glaciated areas of Elbruz. Compilation of glacio-geomorphological map at 1:10,000.

Work completed. 1) A glacio-geomorphological map of the northern and western glaciated areas of Elbruz has been compiled on the basis of aerial photographs.

2) A paper entitled "The Glaciers of the Northern Slope of Mt Elbruz" has been prepared and sent to print.

6. Information on activities of glaciological party.

All work took place on the southern slope of Elbruz Mt. (on the B. Azau glacier and at the Glacial Base).

Purpose of investigations: a study of the conditions of formation and the structure of the Elbruz glaciers with the aid of spore and pollen analysis, petrographic methods, and other techniques.

The investigations were conducted on the B. Azau glacier and in the area of the Glacial Base. Two crevasses were studied in the vicinity of Glacial Base, the 1st below the ice fall on Garabashi glacier, measuring 7 m in depth, the 2nd near Shelter 9 (elevation 4000 m), measuring about 20 m in depth.

Ice samples were gathered from them for microphotography, and the dimensions of the ice crystals at various depths in the crevasse were then determined. Samples were also taken of dead ice near Glacial Station and on the B. Azau glacier.

Microscopic investigations and photography took place in a specially-designed laboratory within the dead ice deposit near Glacial Base.

Samples of snow and ice were also removed from these crevasses for spore and pollen analysis to determine the time of year at which specific layers had formed.

2 samples of water and of red snow were taken from the surface of Garabashi glacier for diatom analysis. 3 ice samples have been gathered for a chemical analysis of the composition of active and dead ice.

All the snow and ice samples gathered for various analyses are being processed at the present time.

7. Information on activities of thermophysical group.

During the IGY period, work has been in progress toward a thermo-physical survey of the southern slopes of the Elbruz glaciers, using the methods and equipment recommended by the Glaciology Work Group of the IGY Committee.

Activities included the drilling of 5 one-meter holes, layer-by-layer temperature determinations, and the determination of densities within the upper firn snow layer:

Three profiles were plotted:

1) Glacial Base (3760 m) - upper end of Shelter 9 (4300 m);

2) Shelter 11 (4200 m) - Pastukhov Shelter (4800 m);

3) Pastukhov Shelter (4800 m) - Col (5300 m).

The drill holes were spaced at elevation intervals of roughly 100 m from Glacial Base to Pastukhov Shelter.

Purpose of Organizing Investigations:

1) to differentiate vertical ice-formation zones on the southern slope of Elbruz;

2) to calculate the heat content and cold reserves in the upper active layer of the glacier.

Snow density determination was carried out by means of a layer density gage weighted in units of density.

Measurement of ice density were also made by the hydrostatic weighting technique.

In all, 14 holes were drilled of a total length of 60.5 m, the average hole depth being 4.4 m. About 60 temperature measurements were made.

8. Information on activities of paleo-glaciological party.

The work of the paleoglaciological party is based on reconnaissance studied. The purpose of the work is to study traces of ancient glaciation in the vicinity of Elbruz, the study of the geological and geomorphological effects of relief-forming processes during glacial times, and the compilation of a local stratigraphic diagram of Quaternary deposits. During 1956, 1957 and 1958, investigations took place in the valleys of rivers Baksan, Malka, Kuban' and all its affluents (including the Teberda R. valley to the west and the Adyr-Su and Adyl-Su R. valleys to the east), as well as in the Kuban'-Malka and Malka-Baksan watersheds. In 1959 investigations will be expanded to include the adjacent areas of the northern slope of the Greater Caucasus and piedmont plains.

9. Information on the activities of the winter party at "Glacial Base."

1. Thermo-physical observations.

a) Stationary temperature observations at the 20-m drill holes (daily at drill-hole No. 1, once every three days in accordance with a running curve at holes nos. 2 and 3).

b) Determination of ice densities (twice a month).

2. Accumulation and ablation observations.

a) Snow-measurement surveys along profiles (daily). Determination of density of upper snow layer along profiles (once every ten days).

b) Observations of wind-blown transfer (during every snow storm).

c) Visual observation of accumulation and ablation above "Shelter 11".

Observations involve the use of the following equipment:

1) Temperature measurement: use was made of copper resistance thermometers of type ZTM-Khl with 2-a graduation and a rating of 53 ohms, and platinum resistance thermometers of type ZTM-310 with 2-a graduation and a 100 ohm rating. A three-lead circuit was used for measurement. MVU-49 bridges being used as meter.

2) Snow-measurement surveys: wooden 4-meter rods graduated in centimeters.

3) Snow density measurements are taken by means of the standard density gage used by the Hydro-Meteorological Service.

4) Snow-storm transfer: snow-storm gages of model BO-2.

5) Ice density determinations were by the standard hydrostatic weighing technique.

CAUCASUS IGY 1958

Fig. 1. View of Elbruz from south. Gora-bashi glacier is in foreground.

Fig. 2. Glaciological station of Elbrus expedition at village of Terskol. Elevation: 2100 m.

Fig. 3. View of Elbruz from north.

Fig. 4. View of Elbruz from south. Glacial Base. Elevation 3967 m.

Fig. 5. Irik glacier. Working with theodolite.

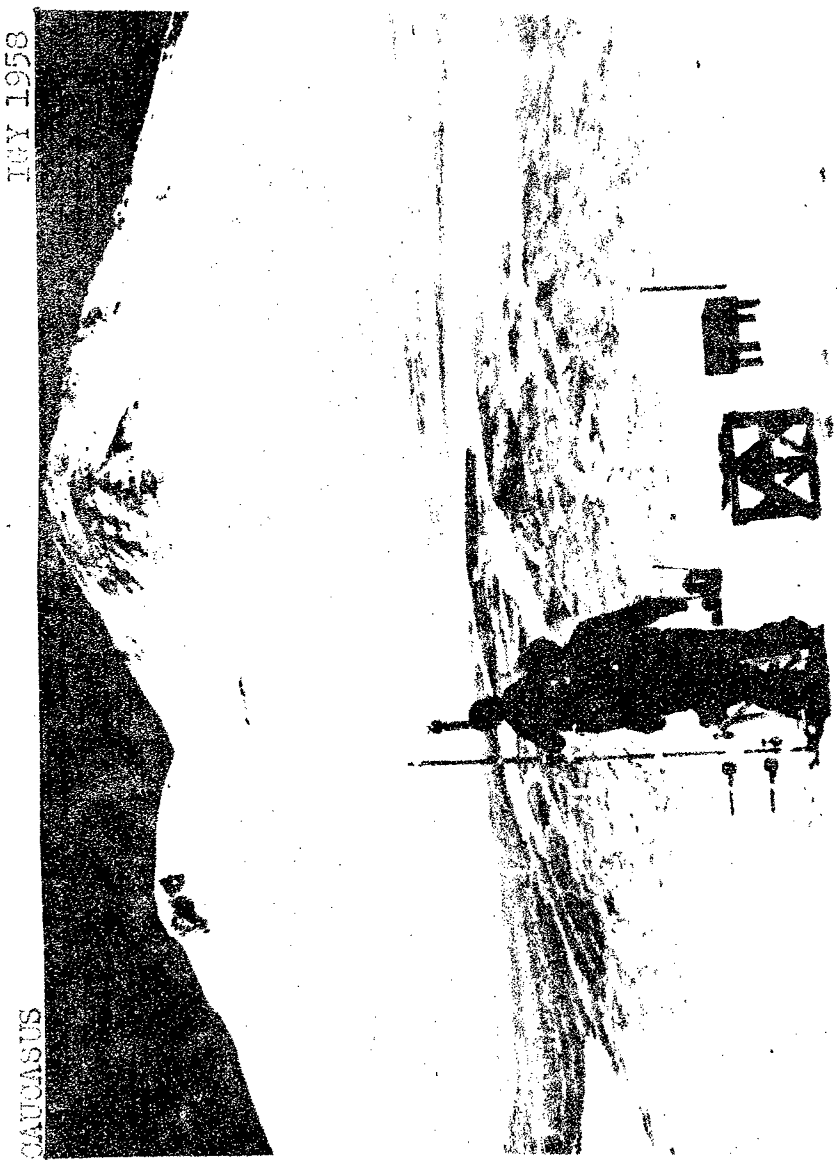

Fig. 6. Elbruz. Weather observations on glacier.

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